HIGHWAY ENGINEERING

AS PRESENTED AT

The Second International Road Congress

BRUSSELS, 1910

BY

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FIRST EDITION

First Thousand

NEW YORK: JOHN WILEY & SONS

LONDON: CHAPMAN & HALL, LIMITED

1911

COMPOSED AND PRINTED BY THE PUBLISHERS PRINTING CO., NEW YORK, U.S.A.

Dedicated to

M. ALBERT MAHIEU

Ingenieur en Chef des Ponts et Chaussées de France, Secrétaire-Général du Bureau Exécutif de l'Association Internationale Permanente des Congrès de la Route

PREFACE

THE object of the authors in writing this book was to render available to those interested in the progress of highway engineering the large mass of information relative to the construction and maintenance of roads and pavements which was presented by the various reporters and contributors at Brussels in 1910.

The authors, fully appreciating the valuable knowledge which may be acquired by a close observance of the practice of highway engineering in the various countries of the world and believing that it is possible in many cases to profit by the successes and failures of others who have worked in similar fields and thus avoid costly duplication of experimental work and the waste of public and private funds through the adoption of methods which have resulted in unsatisfactory roads and pavements, wish to emphasize the fact that the subject of foreign practice has not received the attention it deserves by American engineers.

The main part of the book is devoted to the presentation of the fundamental facts and salient opinions contained in the one hundred and twenty-four papers, aggregating over two thousand pages, submitted to the Congress and the discussions at the many sessions of the Congress which occupied over two hundred pages of the "Report of the Proceedings of the Congress," recently published by the

Association. It should be borne in mind that the reporters selected by the Executive Committee were instructed to cover in their reports the progress in the particular field assigned relative to the practice of the countries which they represented. The conclusions which were finally adopted by the Congress were the outcome of thorough consideration and ofttimes strenuous debates by highway engineering experts from all parts of the world. It is self-evident that through the medium of an International Road Congress a very comprehensive review of foreign practice is presented.

The plan adopted in the compilation of the book has been to collate the material under headings familiar to American engineers. Discussions in every case follow the reporter's name, hence quotation marks were not used although in some cases the words of the reporters were employed, but generally the object of the authors was attained by presenting the important ideas of the reporters in abstract. The discussions on a given topic relative to the practice in a given country have been congregated while the groups thus formed have been arranged in alphabetical order in each chapter.

As some readers may desire to communicate with the reporters, the names, titles and addresses of all contributors to the discussions on a given topic have been listed at the beginning of each chapter as well as being given in connection with the list of reports and communications on the various questions in Chapter I.

The United States standard equivalents of the various foreign monetary values, weights and measures have been

given in order to facilitate the comparison of the practice and cost data presented by engineers from many countries.

The authors are under obligations to Messrs. Earl R. Donle, Clifford M. Hathaway, and Irving W. Patterson for valuable assistance rendered in connection with the collaboration of the book, translations and proof-reading.

Columbia University,
New York City,
August 15, 1911.

A. H. B.
H. B. D.

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CHAPTER I

THE CONGRESS

The First International Road Congress was held at Paris in 1908 under the auspices of the French Government. It was attended by over 2,250 persons affiliated with various branches of highway engineering. The world-wide interest in the proceedings of the Congress was shown by the participation of representatives from twenty-seven countries in the discussion at the various sessions. A total of ninety-eight papers covering many phases of highway engineering and allied subjects were prepared for this Congress.

At the plenary sitting of the First Congress held on October 17th, 1908, the following resolutions were adopted creating the Permanent International Association of Road Congresses.

1. A Permanent International Commission of Congresses is established with the object of furthering progress in the construction, maintenance, and use of the road,

and also of providing in the future for continuity in the work of the Congress.

2. This Commission is composed of members including:—(*a*) The governments, societies, and other public bodies of all countries. (*b*) Individual members.

3. The Governing Body of this Commission is provisionally a Permanent International Council composed of the Presidents and Vice-Presidents of the General Board and of the Sectional Boards of the First International Road Congress held at Paris in 1908.

4. This Permanent Council is in its turn administered by a provisional Standing Board which shall sit at Paris.

Each country is represented on this Board by one or two members of the Permanent Council. The proceedings of the Board will be prepared and carried out by an Executive Committee, sitting at Paris and composed of three members:—

M. Lethier, *Inspector-General of Bridges and Roads of France,* President.

M. Ballif, *President of the Touring Club of France,* Vice-President.

M. Mahieu, *Chief-Engineer of Bridges and Roads of France,* Secretary.

5. The Permanent Council is charged with the drawing up of the Statutes of the Permanent International Commission of Road Congresses and with the immediate application of these statutes.

6. The Permanent Council is charged with the organization of the next Road Congress, which will be held at Brussels in 1910.

7. The Permanent Council is instructed to study the question whether it would not be desirable to centralize

in a special organization the results obtained from the various experiments made in all countries, and, if necessary, to cause new experiments to be undertaken, and, further, to institute chemical and mechanical experiments in tar and other materials (as is done for materials of construction, such as steel, cement, etc.), with a view to fixing a standard for such substances.

The Second International Road Congress was held in Brussels from July 31st to August 7th, 1910, under the patronage of His Majesty the King of the Belgians, Albert I.

The Congress was presided over by the President, M. Lagasse de Locht, *Director-General of Bridges and Roads of Belgium*, while M. E. Walin, *Chief Engineer of Bridges and Roads and Director of Highways to the Ministry of Public Works of Belgium*, officiated as General Secretary.

The total number of members of the Second Congress was 2,118 representing thirty-eight countries. The table of membership at the end of this chapter contains interesting information relative to the distribution of members among the various countries and the classification of members.

The following program gives the questions discussed and a list of the authors and the titles of the 124 reports and communications presented at the Second Congress.

SECTION I

CONSTRUCTION AND MAINTENANCE

Sub-division A: Construction and Maintenance Outside the Large Towns

First, Second and Third Questions

Third Communication

Norway

1. Skougaard, J., *Director General of Bridges and Roads,* Christiania. Metalled and paved roads in Norway; materials used in their construction and maintenance.

First Question

Metalled and Paved Roads. Use of Binding Materials in the Construction of Metalled Roads. Use of Trackways in the Paved Roads. Progress Made in Combating Wear and Tear and Dust

I. General Reporter, M. Macquet, *Chief Engineer and Director of Bridges and Roads,* Brussels.

Germany

2. Sperber, *Chief Engineer,* Hamburg, and
   Franze, Gustav, *Commissioner of Public Works,* Frankfort-on-the-Main. Diminution of the dust-plague on the public roads of German cities.

Austria

3. Bradaczek, Theodor, *Imperial Commissioner of Public Works,* Prague. Construction and maintenance of the Imperial Roads in the Kingdom of Bohemia.

Belgium

4. Froidure, Eugène, *Principal Engineer of Bridges, and Roads,* Ypres, and
Verstraete, Richard, *Engineer of Bridges and Roads,* Bruges. Structure of metalled roads in Belgium; various methods of tar painting roads in Belgium; watering with chloride of calcium and resurfacing with use of tar.

Bulgaria

5. Karakoulakoff, Paul, *Engineer, Ministry of Public Works,* Sofia. The country highroads in the Kingdom of Bulgaria.

Spain

6. Sanchis, Vincent, *Engineer of Highways, Canals and Harbors,* Valencia. Metal trackways for ordinary vehicles.

United States

7. Blanchard, Arthur H., M. Am. Soc. C. E., *Deputy Engineer, Rhode Island State Board of Public Roads,* Providence, R. I. Investigations of the use of various bituminous binders in the construction of State Roads in Rhode Island.

United States

8. Crosby, Walter W., M. Am. Soc. C. E., *Chief Engineer to the Maryland Geological and Economic Survey,* Baltimore, Md. The use of binding materials in the construction of macadamized roadways.

United States

9. Fletcher, Austin B., M. Am. Soc. C. E., *Secretary, Massachusetts Highway Commission,* Boston, Mass. Protective coatings for macadam roads.

United States

10. Hooker, S. Percy, *Chairman, New York Highway Commission,* Albany, N. Y. Maintenance and repair of stone roads in the United States.

United States

10 *bis.* Parker, Harold, M. Am. Soc. C. E., *Chairman, Massachusetts Highway Commission,* Boston, Mass. Description of the method of building a road to meet the requirements of modern traffic in the United States.

France

11. LeGavrian, P., *Engineer of Bridges and Roads,* Versailles. Metalled and paved roads. Use of binding materials in the construction of metalled roads. Use of trackways in the paved roads. Progress made in combating wear and tear and dust.

France

12. Saunier, Honoré, *District Inspector,* Rouen. Hydraulic binders for macadam roads. Trackways. Progress in combating wear and tear and dust.

Great Britain

13. Drummond, Robert, *County Surveyor,* Renfrewshire, Paisley, Scotland. Metalled and paved roads in Scotland. Use of trackways in paved roads.

Hungary

14. Glasner, Antoine, *Engineer,* Budapest. Metalled roads and paved roads outside the large towns in Hungary.

Italy

15. Tedeschi, Massimo, *Engineer*, Turin, and Corazza, Cesare, *Engineer*, Turin. Metalled roads in Italy.

Switzerland

16. Étier, Paul, *Councilor of State*, Lausanne. Metalled roads in Switzerland. Progress of the fight against wear and tear and dust.

Second Question

Foundation and Drainage of Roads. Methods of Carrying Out the Work

II. General Reporter: Michez, H., *Chief Engineer and Director of Bridges and Roads*, Arlon.

Austria

17. Böltz, Johann, *Imperial Chief Commissioner of Public Works*, Laibach. Construction and maintenance of the Imperial Roads in the Duchy of Carniola.

Belgium

18. Van Volsom, Edgard, *Engineer of Bridges and Roads*, Brussels. Foundation of roads. Methods of carrying out the work in Belgium.

United States

18 *bis*. Pierce, Vernon M., *Chief Engineer U. S. Office of Public Roads*, Washington, D. C. The foundation and drainage of country roads in the United States.

France

19. Pierret, Léopold, *Chief Engineer of Bridges and Roads,* Amiens. Systems of foundation and drainage of metalled and paved roads.

France

20. Lelièvre, Charles, *Honorary District Inspector,* Versailles. Foundations and drainage of roads. Investigations on the foundation systems in France.

Italy

21. Vandone, Italo, *Chief Engineer of the Province of Milan.* Foundation and drainage of the road from Binasco to Rosate, Province of Milan.

Third Question

Laying Light Railways and Tramways on Roads. Advantages and Disadvantages. Effect on the Various Methods and the Cost of Maintenance

III. General Reporter: Bonnevie, Auguste, *Chief Engineer of Railroads,* Brussels.

Germany

22. Gerlach, Friedrich, *Imperial and Municipal Commissioner of Public Works,* Berlin. Laying light railways and tramways on roads with special consideration of municipal roads.

Austria

23. Ullman, G., *Chief Engineer of Tramways,* Vienna. Laying light railways and tramways on Austrian roads.

Spain

24. Spiteri, José Rodriguez, *Chief Engineer of Highways, Canals and Harbors,* Malaga. Laying light railways and tramways on Spanish roads.

France

25. Galliot, François, *Chief Engineer of Bridges and Roads,* Dijon. Laying light railways and tramways on roads. Advantages and disadvantages. Effect on the system and on the cost of maintenance.

Great Britain

26. Wynne-Roberts, R. O., M. Inst. C. E., F. R. San. Inst., Westminster, London, England. Laying light railways in Great Britain.

Hungary

27. Von Sztrókay, Stéfan, *Chief Engineer,* Budapest. Laying light railways and tramways on roads in Hungary. Advantages and disadvantages. Effect on the system and on the cost of maintenance.

Italy

28. Toller, Gino, *Engineer,* Milan. Light railways and tramways on the roads in Italy.

Netherlands

29. Gelinck, W. G. C., *Engineer of Waterways,* Assen, and

    Van Heyst, D. A., *Engineer of Waterways,* Zütphen. The tramways and National Roads of the Netherlands.

Sub-division B: Construction and Maintenance in the Large Towns

Fourth Question

Cleansing and Watering. Necessity or Utility. Methods in Use. Their Cost. Comparison of Various Methods

IV. General Reporter: Loppens, Georges, *Engineer, Provincial Engineering Department,* Liége.

Germany

30. Höpfner, Paul, *Imperial and Municipal Commissioner of Public Works,* Cassel. Cleansing and watering. Necessity or utility. Methods in use. Their cost. Comparison of various methods.

Austria

31. Kellner, Dr. Hans, *Director of Public Works,* Brünn. Cleansing and watering on Austrian roads.

Spain

32. Spiteri, José Rodriguez, *Chief Engineer of Highways, Canals and Harbors,* Malaga. Cleansing and watering on Spanish roads.

France

33. Bret, E., *Chief Engineer of Bridges and Roads,* Paris. Road scavenging, cleansing and watering in large cities of France.

Great Britain

34. Yabbicom, Thomas H., M. Inst. C. E., *City Engineer,* Bristol, England. Cleansing and watering streets in the great towns of England, Scotland and Ireland.

Hungary

35. Ballö, Alfred, *Commissioner of Street Cleaning,* Budapest. Street cleaning methods in the City of Budapest.

Monaco

36. Berthet, E., *Councilor of State,* Monaco. Cleansing and watering; necessity or utility; methods in use; their cost; investigations on the roads of the Principality of Monaco.

Norway

37. Roshaŭw, J. C., *Director of Highways,* Christiania. Road scavenging, cleansing and watering in Christiania.

Fifth Question

Choice of the Surfacing Materials.

V. General Reporter, Lemeunier, R., *Chief Engineer and Director of Highways,* Antwerp.

Germany

38. Bredtschneider, August, *Commissioner, Board of Public Works,* Charlottenburg;

    Hörburger, *Member, Board of Public Works,* Munich;

    Eisenlohr, *Director, Board of Public Works,* Strasburg;

    Fleck, Georg, *Commissioner, Board of Public Works,* Dresden. Inquiry on the methods of surfacing highways in the German towns exceeding 50,000 inhabitants.

Belgium

39. De Jaegere, Alberic, *Civil Engineer,* Antwerp. Different methods of road surfacing as used in the large cities of Belgium.

Egypt

40. Lloyd Davies, D. E., M. Inst. C. E., *Chief Engineer to the Municipality of Alexandria.* Road making in Alexandria.

Spain

41. Lafarga, Prospero, *Engineer of Highways, Canals and Harbors,* Alicante. Choice of the surfacing materials; experiments made and results obtained in some Spanish towns.

United States

42. Rablin, John R., M. Am. Soc. C. E., *Chief Engineer, Metropolitan Park Commission,* Boston, Mass. Construction and maintenance of parkway roads in the United States.

France

43. Mazerolle, L., *Engineer of Bridges and Roads,* Paris. Research of the form of surface to be employed for a large city; factors to be taken into account when making a choice. Various methods of surfacing roads; advantages and disadvantages of the surfaces used in Paris. Surfacing footways.

Great Britain

44. Crompton, Col. R. E., M. Inst. C. E., *Royal Automobile Club,* London, England. On the construction and maintenance of the roadways of large towns in England.

Great Britain

45. Gullan, Hector F., *Superintendent of the Works Department of the City and County Borough of Belfast,* Ireland. Choice of the surface and of the system of construction; first capital expenditure, vitality and maintenance cost of various surfaces employed in Great Britain.

Hungary

46. Fock, Edouard, *Chief Engineer,* Budapest.

Menczer, Bela, *Chief Engineer,* Budapest. Construction and maintenance of the roads of large towns in Hungary. Choice of the surfacing materials.

Italy

47. Cattaneo, Paolo, *Engineer, Office of Municipal Engineer,* Milan. Stone pavements in Italy.

Switzerland

48. Wenner, Victor, *City Engineer,* Zurich.

Schlaepfer, Arthur, *Street Inspector,* Zurich. Choice of the road surfacing materials in Switzerland.

Sixth Question

Methods of Carrying Out Road Work in Connection with Lighting and Water Supply

VI. General Reporter, Fourmanois, A., *Engineer, Technical Department of the Province of Brabant,* Brussels.

Germany

49. PETERS, FRITZ, *Commissioner of Public Works,* Magdeburg;

    STEUERNAGEL, KARL, *Commissioner of Public Works,* Cologne;

    VON SCHOLTZ, A., *Commissioner of Public Works,* Breslau;

    VON MONTIGNY, *Commissioner of Public Works,* Aix-la-Chapelle; and

    HENTRICH, HUBERT, *Commissioner of Public Works,* Crefeld. Method of carrying out road work in connection with lighting and water supply.

Belgium

50. LEMEUNIER, RICHARD, *Chief Engineer of Bridges and Roads,* Antwerp.

    DE HEEM, PAUL, *Engineer of Bridges and Roads,* Antwerp. Method of carrying out road work in connection with lighting and water supply at Antwerp.

France

51. LIDY, GEORGES, *Chief Engineer of Bridges and Roads,* Bordeaux. City streets; how they are controlled and administered; method of carrying out the works; their effect on the suitability of the street to the traffic.

Great Britain

52. SILCOCK, EDWARD JOHN, *Past President of the Society of Engineers,* Westminster, London, England. Methods of carrying out road maintenance and repair work in connection with underground pipes.

Hungary

53. Mihályfi, Joseph, *Technical Councilor*, Budapest, and
Jász, Didier, *Technical Councilor*, Budapest. Lighting and water supply in connection with road construction in Budapest.

Netherlands

54. Walland, C. B. J., *Engineer of Public Works*, The Hague. Method of construction of roads along tram lines within city areas.

SECTION II

USE AND TRAFFIC

Seventh Question

Influence of Weight and Speed of Vehicles on Bridges and Other Special Structures

VII. General Reporter, Christophe, Paul, *Principal Engineer of Bridges and Roads*, Brussels.

Belgium

55. Descans, Léon, *Engineer of Bridges and Roads*, Ghent. The influence of the weight and speed of vehicles on the strength of bridges.

France

56. Résal, Jean, *Inspector-General of Bridges and Roads*, Paris. Influence of weight and speed of vehicles on the stability and upkeep of special structures.

Great Britain

57. Beaumont, W. Worby, M. Inst. C. E., *Consulting Engineer*, London, England. Influence of speed and weight of vehicles on bridges and other structures.

Hungary

58. De Novák, François, *Technical Councilor to the Royal Ministry*, Budapest. Influence of weight and speed of vehicles on special structures.

Eighth Question

Road Vehicles: Conditions to be Fulfilled by Horse or Mechanically Driven Vehicles in Order that They may Neither Cause nor Suffer any Extraordinary Damage to or from the Road

VIII. General Reporter, Heirmann, Edmond, *Engineer*, Brussels.

France

59. Lumet, Georges, *Engineer of Arts and Manufactures*, Paris. Road vehicles.

Great Britain

60. Mallock, A., E. R. S., *Royal Automobile Club*, London, England. Relative effect on roads of hard and soft tires.

Netherlands

61. Steffelaar, L. C., *President of the Touring Club of Netherlands*.

Janson, J. H., *Secretary of the Touring Club of Netherlands*. Some experiments to ascertain the

influence of the width of the tires of wheels of vehicles upon the more or less rapid destruction of road coverings and upon the tractive force of vehicles.

Ninth Question

CONDITIONS FOR THE USE OF PUBLIC SERVICE CONVEYANCES OTHER THAN TRAMWAYS: ADVANTAGES AND DISADVANTAGES, CAPACITY, COST, ETC.

IX. General Reporter, HANSEZ, JULES, *President, Touring Committee, Royal Automobile Club,* Brussels.

Belgium

62. DE FUISSEAUX, H. L., *Chief Engineer and Director, Autobus Company,* Brussels. Conditions for the exploitation of public service road conveyances other than tramways.

France

63. MARIAGE, A., *Chief Engineer, Omnibus Company,* Paris. Conditions for the use of public service conveyances other than tramways. Advantages and disadvantages. Capacity, cost, etc. Investigations on the conditions in France.

France

64. PÉRISSÉ, LUCIEN, *Engineer of Arts and Manufactures,* Paris. Operation of automobiles as public service conveyances.

Great Britain

65. SMITH, EDWARD SHRAPNELL, *Member of Committee, Royal Automobile Club,* London, England. Motor omnibus or electric tramcar?

Hungary

66. De Hevesy, Guillaume, *Civil Engineer,* Budapest. Economical transport of industrial goods.

Italy

67. Albertini, Antoine, *Director of Engineering Department, Province of Modena.* Conditions for the use of public service conveyances other than tramways in Italy.

COMMUNICATIONS

SPECIAL REPORTS

United States

1. Pennybacker, James E. Jr., *Chief of Road Management, Office of Public Roads, U. S. Department of Agriculture,* Washington, D. C. Road administration in the United States.

Great Britain

1 *bis*. Wakelam, H. T., M. Inst. C. E., *County Engineer of Middlesex,* Westminster, London, England. The rule of the road.

SECTION I

CONSTRUCTION AND MAINTENANCE

First Communication

USE OF MECHANICALLY DRIVEN PETROL MOTOR ROLLERS

Belgium

2. THOMAS, EDMOND, *Civil Engineer*, Brussels. Petrol motor road rollers.

France

3. PELLÉ, C. F. J., *Engineer of Bridges and Roads*, Paris. The employment of oil or petrol driven road rollers.

Great Britain

4. WAKELAM, H. T., M. Inst. C. E., *County Engineer of Middlesex*, Westminster, London, England. Petrol motor rollers.

Second Communication

ROAD MAKING TOOLS AND IMPLEMENTS OTHER THAN MECHANICALLY DRIVEN ROLLERS, SCARIFIERS, ETC.

Austria

5. MACHNITSCH, RUDOLF, *Imperial Chief Engineer*, Görz. Road making tools and implements in Austria.

France

6. PONS, ALFRED, *District Inspector*, Montpellier. Road making tools and implements other than road rollers.

France

7. Verger, Casimir, *Assistant Engineer of Bridges and Roads,* Paris. Road plant of the City of Paris.

Italy

8. Gola, Emilio, *Engineer,* Milan. Road cleaning machines.

Russia

9. Waicht, Ceslav, *Engineer of Highways,* Warsaw. Machines employed in Russia for the repair and maintenance of roads.

Third Communication

Various Materials in Use for the Purpose of Construction and Maintenance. Conditions to be Fulfilled. Tests, Units to be Adopted

Germany

10. Bredtschneider, August, *Commissioner of Public Works,* Charlottenburg. Laboratory tests made with various asphaltic materials.

Austria

11. Walbaum, Ludwig, *Imperial Commissioner of Public Works,* Gratz. Special study of the roads of Styria.

Belgium

12. Cornu, Louis, *Principal Engineer of Bridges and Roads,* Arlon, and
    Camerman, Emile, *Engineer,* Brussels. Various materials in use for the purpose of construction and maintenance; conditions to be fulfilled; tests.

Spain

13. Bores y Romero, Don José, *Chief Engineer of Highways, Canals and Harbors,* Lérida. Various materials in use for the purposes of construction and maintenance; conditions to be fulfilled; tests.

United States

14. Hubbard, Prévost, *Chemist, Office of Public Roads,* Washington, D. C. The physical and chemical characteristics of bituminous road materials.

United States

15. Ross, Charles W., *Street Commissioner,* Newton, Mass. Difficulties of road building in the United States.

France

16. Mesnager, Augustin, *Chief Engineer of Bridges and Roads,* Paris. Natural stones used in the construction and maintenance of roads.

Great Britain

17. Wynne-Roberts, R. O., M. Inst. C. E., F. R. San. Inst., Westminster, London, England. Various materials in use for the purposes of construction and maintenance of roads. Conditions to be fulfilled. Units to be adopted.

Italy

18. Touring Club of Italy. Actual studies in Italy on the coefficients of quality of metalling materials.

Netherlands

19. Van Löben Sels, M. J., *Vice-President, Netherlands Association of Brick Manufacturers,* Nimwegen. Method followed in Holland to make roads of greater resisting power.

Russia

20. Tsvétkovsky, Constantin, *Engineer of Highways,* Warsaw. The use of vitrified clinker bricks for the purpose of construction and maintenance of roads in Russia.

Russia

21. Mikhailoff, Paul, *Engineer of Highways,* St. Petersburg. Remarks on Russian roads.

Fourth Communication

Construction of Footways in Towns

France

22. Le Roux, Nicolas, *Engineer of Bridges and Roads,* Angers. The laying down of footpaths in towns.

Great Britain

23. Trusler, George D., A. M. C. E., *Civil Engineer,* London, England. Footpaths in the City of London.

Netherlands

24. Hendricks, C. J., *Manufacturer of Paving Bricks,* Woerden. Sidewalks paved with brick.

Portugal

25. Roldan y Pego, Manuel, *Engineer,* Lisbon, and Mello de Mattos, José, *Engineer,* Lisbon. Footways of small setts. The paving of public places and sidewalks in Lisbon.

Fifth Communication

Removal of Snow and Ice

Austria

25 *bis.* Spängler, Ludwig, *Municipal Director of Streets,* Vienna. Removal of snow.

Belgium

26. Courtois, Auguste, *Principal Inspector of Bridges and Roads,* Bastogne. Removal of snow and ice.

France

27. Mazerolle, L., *Engineer of Bridges and Roads,* Paris. Investigations on the removal of snow in Paris.

France

28. Wilhelm, Ivan, *Chief Engineer of Bridges and Roads,* Gap. The removal of snow and ice outside of towns

Italy

29. Cinque, Victor, *Chief Engineer of the Province of Brescia.* Removal of snow and ice in Italy.

Russia

30. Mikhaïloff, Paul, *Engineer of Highways,* St. Petersburg. Removal of snow in Russia.

SECTION II

USE AND TRAFFIC

Sixth Communication

Road Signs. Measures Taken to Carry Out the Resolutions of the Paris Congress

Austria

31. Bradaczek, Theodor, *Imperial Commissioner of Public Works,* Prague. Road signs. Erection and equipment of sign posts. Application of road markings and number of notice boards required on the public roads in the Kingdom of Bohemia.

Belgium

32. Van Zeebroeck, Ed., *Delegate of the Touring Club of Belgium,* Brussels;
Colard, H., *Delegate of the Touring Club of Belgium,* Brussels;
Fourmanois, A., *Delegate of the Touring Club of Belgium,* Brussels; and
Van Meerbeeck, H., *Delegate of the Touring Club of Belgium,* Brussels. The conventional sign on the caution sign post.

France

33. Chaix, Edmond, *President, Touring Committee, Automobile Club of France,* Paris. Road signs. Measures taken to carry out the resolutions of the Paris Congress. Resolutions passed by the International Meeting of Touring Societies held on December 1st, 1908, and by the International Diplomatic Conference held on October 8th, 1909.

Hungary

34. Némethy, Josef, *Royal Chief Engineer*, Zilah. Road signs. Kilometre marking of the roads; information in regard to direction, distances, heights, obstacles and dangerous places.

Italy

35. Toller, Gino, *Engineer*, Milan. Sign posts of the Touring Club of Italy.

Netherlands

36. Pos, G. A., *Vice-President, Touring Club of Netherlands*, Baarn. Road signs. Measures taken to enact the resolution of the International Conference held on December 1st, 1908.

Seventh Communication

Various Kinds of Soft Tires: Use, Advantages, Disadvantages, etc.

Belgium

37. Hansez, Jules, *President, Touring Committee, Royal Automobile Club*, Brussels. Different kinds of flexible tires. Use, advantages and disadvantages.

France

38. Ferrus, Commandant L., *Member, Automobile Club of France*. History of the various kinds of tires. Use, advantages and disadvantages.

France

38. *bis*. Baudry de Saunier, L., *Member, Automobile Club of France*. Necessity of elastic tires for rapidly moving vehicles. Pneumatic tires.

Italy

39. Arisi, T., *Engineer, Member, Automobile Club of Italy.* Different kinds of resilient tires.

Eighth Communication

Census of Traffic and Tonnage. Methods in Use and Results Obtained. Units Adopted

Bulgaria

40. Guéchoff, Stéfan Chr., *Director-General of Highways,* Sofia. Census of traffic and tonnage hitherto carried out in Bulgaria.

France

41. Moullé, A., *Chief, Division of Highways and Bridges, Ministry of Public Works,* Paris. Census of traffic on the National Roads of France.

Italy

42. Vandone, Italo, *Chief Engineer, Province of Milan.* Various censuses of the number of vehicles and of the tonnage in some provinces of Italy.

All the reports and communications were distributed to the members of the Congress many weeks previous to the opening of the Congress at Brussels. The papers were printed in the three official languages: English, French and German.

The Executive Bureau had appointed for each question a general reporter who reviewed all the reports submitted relative to the assigned question and formulated conclusions which were based to a great extent upon the recommendations of the various reporters. The general reports on the

nine questions were bound together and distributed to the members on the first day of the Congress.

The Congress was divided into two sections with a further sub-division of Section I into sub-sections A and B. A total of eleven sectional meetings were held. The technical sessions were devoted to the consideration of the tentative conclusions which were proposed by the general reporters relative to the various questions, and the adoption of conclusions which would be submitted to a general meeting of the Congress.

The proceedings of the various sessions were carried on in the three official languages of the Congress, English, French and German; that is, after a discussion had been given in one language, a digest of the same was immediately given in the other two languages. The English-speaking members of the Congress, besides taking an active part in the regular meetings, also met at various times for the discussion of the tentative conclusions and the consideration of other subjects of mutual interest.

At the closing session of the Congress held on Saturday, August 6th, 1910, the conclusions given in Chapter XXIV were adopted without discussion.

Classification of Members of the Second International Road Congress

Order No.	Nationalitie represented at the Congress	Delegates of Government: To the I. P. C. and Second Congress	Delegates of Government: To the Second Congress Only	Delegates of Corporations: Permanent Members	Delegates of Corporations: Temporary Members	Exhibitors	Donors	Members: Permanent Members of the Association	Members: Temporary Members at the Second Congress Only	Members: Associates	Total Number of Members at the Congress
1	Algeria	1	...	...	...	...	...	5	...	...	6
	Germany: Empire	1	1								
	Prussia	7	...								
	Bavaria	1	3								
	Saxony	1	1								
2	Baden	1	...	23	27	9	1	110	49	37	276
	Brunswick	1	...								
	Hamburg	1	...								
	Alsace-Lorraine	1	1								
3	Argentine	1	...	...	...	...	...	...	...	...	1
4	Austria	3	15	5	7	...	1	28	36	18	113
5	Hungary	3	1	3	1	...	...	11	6	3	28
6	Belgium	3	14	2	85	26	67	71	299	54	621
7	Brazil	...	...	1	1	...	...	2	...	...	4
8	Bulgaria	1	1	...	...	...	...	2	...	1	5
9	Canada	...	...	...	...	...	...	...	2	...	2
10	China	1	...	...	...	...	...	...	1	...	2
11	Colombia	1	...	...	...	...	...	...	...	...	1
12	Cuba	1	1	...	...	...	...	1	...	...	3
13	Denmark	1	1	3	...	...	...	4	2	...	13
14	Egypt	...	...	...	...	...	...	2	...	...	2
15	Spain	1	3	2	1	...	...	19	6	7	39
16	United States	...	12	2	...	...	...	28	9	4	55
17	France	17	12	90	32	15	1	261	27	56	511
18	Great Britain	...	3	14	2	1	1	68	53	18	160
19	Greece	1	...	...	...	...	...	2	1	...	4
20	British India	...	1	...	...	...	...	...	...	...	1
21	Indo-China	...	...	...	...	...	...	...	1	...	1
22	Italy	...	...	3	5	2	...	24	15	7	56
23	Japan	...	5	...	...	...	...	...	...	...	5
24	Luxemburg (G.-D.)	1	...	...	...	...	...	...	4	1	6
25	Mexico	1	1	1	...	...	...	2	1	...	6
26	Monaco (Princip.)	2	...	...	...	...	...	...	...	...	2
27	Norway	...	1	...	...	1	1	...	2	1	6
28	Holland	1	1	4	3	3	...	24	8	7	51
29	Portugal	1	1	...	1	...	...	6	...	...	9
30	Roumania	3	1	...	...	...	...	9	2	...	15
31	Russia	2	1	1	2	...	...	14	13	2	35
32	Servia	...	...	1	...	...	...	...	...	...	1
33	Siam	1	1	...	...	...	...	...	...	...	2
34	Sweden	...	1	...	...	3	...	7	2	1	14
35	Switzerland	3	...	4	5	2	...	22	8	9	53
36	Tunis	1	...	1	...	...	...	...	...	...	2
37	Turkey	...	2	1	...	...	...	1	...	...	4
38	Uruguay	...	1	...	1	...	...	1	...	...	3
	Total	65	86	161	173	62	72	724	547	228	2,118

CHAPTER II

THE EXHIBITION

The exhibition of road machinery, materials and sections of roads and pavements was located in or adjacent to the Palais du Génie Civil et du Congrès de la Route, which was situated on the grounds of the 1910 Brussels International Exposition.

The exhibit designated "The History of the Road" was located in the court immediately in front of the exhibition hall. Thirteen different forms of construction showing the development of roads and pavements from the time of the Roman Empire to about A. D. 1800, were represented.

Another exhibit of interest from an historical point of view was designated "The History of Paving in Paris." Thirteen different forms of construction were represented in this exhibit, the period covered by the various types dating from the Gallic-Roman period to modern times. The oldest type of pavement shown in this exhibit was of Roman construction and consisted of flagstones set in lime concrete. After Roman occupancy and through the Middle Ages, the streets of Paris received little attention, many of them becoming little better than open sewers. The development of stone paving is shown by five forms of construction in the exhibit, the first being crude paving with rough stones, the second being constructed with small flagstones, about 20 inches or 24 inches square on the top face and about 7½ inches in depth, the third being a pavement of square stone blocks about 8 inches on the

side, the fourth being constructed of sharp pointed flint stones, and the fifth type being cubical blocks very similar to the third form. Next in chronological order came the metalling proposed by Tresaguet, and still later McAdam's system of metalling. The remaining four types exhibited were of modern development, there being two forms of modern stone block pavement, one of asphalt pavement and one of wood block pavement.

In the form of a circle concentric with the circle formed by the exhibit depicting the history of street paving in Paris, was an interesting exhibit of eleven types of paving to be found in the City of Brussels. Four systems of stone block pavement were included in this exhibit. In two of these pavements tamped sand was employed for a foundation, while the foundation of a third was of broken brick covered by a thin layer of sand. A fourth type of stone block pavement had its joints filled with bituminous material. Two types of metalling were represented in this exhibit, the system of Tresaguet and a form of tar macadam. Three types of bituminous pavement completed this exhibit. Two of these pavements were of sheet asphalt construction, one of them being the so-called asphalt comprime composed of powdered rock asphalt and the other being constructed of sand mixed with molten asphalt. A third type of construction employed blocks composed of a fine mineral aggregate mixed with asphalt. There was also included in this exhibit a section of excellent wood block pavement and a section of pavement constructed of vitrified brick which had previously been soaked in bituminous material.

A fourth group constructed in the form of a semi-circle illustrated the history of the development of the cycling

track. The forms of construction represented included a cinder track, a track constructed of broken brick and cinders, a raised metalled track with cross-drain, a vitrified brick track, a scoria brick track, and a track constructed of porphyritic slabs from Nieuport.

Upon one side of the street leading to the court in front of the exhibition hall was an extensive exhibit of modern paving, while upon the opposite side was an equally extensive exhibit of modern forms of metalling. The space in between the exhibition surfaces was paved with brick by the Dutch system. Vehicles were allowed over the entire width of the street, it being possible, therefore, to observe to some extent the adaptability of the various surfaces for traffic from the standpoints of noisiness and slipperiness. In addition to the above exhibitions, cross-sections of many forms of construction were exhibited in brick boxes, the front sides of which were of glass. These cross-sections showed the detailed construction of the pavements from the subsoil to the wearing surface.

An excellent opportunity was afforded by the exhibit of modern paving to study stone block pavements from the standpoint of desirable size, shape, foundation and material. Four sections of square slabs, about 6 inches by 4 inches by 6 inches, constructed of porphyry, quartzite, granite and flint were laid upon sand foundations. Four sections of oblong slabs, about 4 inches by 6½ inches by 6 inches, of the same materials were laid on foundations of broken stone and sand. The same four materials in the form of oblong blocks, 5 inches by 8 inches by 6 inches, were also laid on concrete foundations. A section of old stone blocks redressed and placed on a concrete foundation formed a part of this exhibit. One section of stone block pavement

was laid upon a foundation of slabs of concrete. Two sections of German kleinpflaster were, perhaps, the most attractive features of this exhibit. The small blocks composing one section were made of Swedish granite, while for the other section Riendotte stone was employed. The method of laying these small blocks in arcs adds an oddly artistic appearance to kleinpflaster pavements. The two remaining sections in this exhibit were a pavement of Straatklenkaart bricks and a section of the Dernerbe system of metallic trackways for paved roads.

The exhibit of modern systems of metalling was fully as interesting as the exhibit of modern paving. The oldest method represented in this exhibit was Tresaguet's system of metalling, employing river gravel rolled with a horse drawn roller. Ordinary water bound macadam of quartzite and porphyry mixed and also of porphyry alone were there constructed, while the use of slag as a binder was demonstrated by employing it as a binder for quartzite metalling. Several types of metalled surfaces bound with bituminous material were represented. One section of metalling upon a foundation of flat rubble was treated by the penetration method with tar. Several sections built of bituminous macadam by the mixing method were upon exhibition. Among these were porphyry which had been dipped in hot tar, chalk which had been dipped in hot tar, and the English method of employing tarred slag. An odd method of employing bituminous material, known as the Rhouben system and consisting of a mixture of powdered tar-pitch, small stone, steel filings and cement, was also to be seen in this exhibit.

From the foregoing brief synopsis of exhibits of methods of construction it is apparent that an excellent opportunity

was afforded to observe a great many types of metalled and paved roads, some of which are widely known and others which are not at present to be found except in very restricted localities.

The exhibits of road machinery were extensive and very interesting, since the types of machines manufactured in different countries were congregated and, therefore, could be readily compared. Road rollers, crushing plants, scarifiers, bituminous material distributors, road sweepers and sprinkling carts, and many kinds of small tools were well represented. A very interesting exhibit was that of a complete plant employed in the Aeberli system of constructing tar macadam. This machine cleans, dries, and passes the stone through a bath of cold tar. Gasolene road rollers and motor street sweepers and street sprinklers were shown in several different forms. Many companies dealing in road building materials offered exhibits of their products. Notable among these exhibits were those of several Belgium stone quarry firms.

CHAPTER III

THE EXCURSIONS AND RECEPTIONS

During the long series of meetings held by the Congress a number of excursions and receptions were participated in by members of the Congress, some of which occasions were social in character, while others combined pleasure with an investigation of methods of road and street construction, quarries and other civil engineering works. Some very brilliant fêtes were held in honor of the Congress and by the Congress.

Two excursions were made upon August 2nd, one party visiting the stone quarries of Quenast and another party visiting the quarries at Lessines. The party journeying to Quenast was met at the station, which is practically in the middle of the quarry, by the superintendent of the company who guided the visitors about the works and explained the methods of developing the quarry. The chief product of this quarry is porphyry stone block for paving purposes. The works in the valley where the blocks are finally trimmed were visited first. The sorting and piling of the blocks by size also takes place here. After investigating this part of the work the party journeyed to the main quarry, which is connected with the finishing works in the valley by a tunnel about 400 feet in length. From an elevated point of view the quarry resembled a huge stone amphitheatre about 2,300 feet in circumference, the various stages of working forming very regular steps from top to bottom. About three thousand workmen are

employed in this quarry, the larger part of them being engaged in breaking the huge pieces of stone by various means to sizes suitable for paving block. The rough blocks are taken through the tunnel in cars to the finishing works. Perhaps the most interesting feature of the quarry is the very effective and economical device of connecting the different stages with mechanically hauled trucks. The trucks are carried on travellers which slide along rails which are nearly vertical. The loaded trucks, as they descend, raise the empty trucks. The party visiting Lessines was met by representatives of the municipality and were allowed ample opportunity to inspect the quarries situated in the vicinity. The members were particularly interested in studying the formation of the porphyrytic diorite of the quarries, which material is commonly called porphyry. This stone occurs in funnel shaped masses varying from 160 feet to 330 feet in depth. The members of the Congress later attended a banquet given by the municipality in their honor.

Upon August 6th the members of the Congress visited a section of roadway upon the Avenue Tervueren where experiments with the "Aeberli-Macadam" system were being carried out. The trip was somewhat of a disappointment because the inclement weather had hindered the work to such an extent that the metalled surface had not been prepared. An opportunity was afforded, however, to study the method of preparing the foundation for the metalled surface and also to inspect the machine in operation which is used in this method to coat the aggregate with tar.

The excursion to the quarries of Montfort and to the City of Liége upon August 8th, was very interesting. The

quarries were operated in a different manner from the systems employed at the other quarries previously visited by members of the Congress. The rough stone blocks hewed out in the quarry are lifted by means of windlasses up inclined planes to a higher level where workmen finished the blocks under extensive thatched roofs. The quarry is near the water front, hence the finished materials are transported largely by boat. In addition to stone blocks the company deals largely in broken stone for metalled roads. At a lunch furnished by the company operating the quarries several interesting speeches were rendered. Mr. Kleyer, mayor of Liége, attended the lunch and gave an instructive talk upon the streets of that city. Sandstone sets are used in this city much more frequently than any other type of pavement, the customary foundation being a bed of concrete 5 inches thick covered by $2\frac{3}{4}$ inches of sand. This type of pavement is costly, but Mr. Kleyer stated that it gave very satisfactory results.

The excursion to the Waterfalls of Coo, to Spa and to the Gileppe Dam, upon August 9th, furnished an opportunity for the members to inspect two unique methods of road construction. The scenery in the section traversed, the magnificent spectacle afforded by the Waterfalls of Coo, and the imposing character of the huge stone dam at the Lake of Gileppe, were much appreciated by the party.

The last excursion upon August 10th to the Grottoes of Han and the Citadel of Namur provided an opportunity to inspect an experimental section of the road on the route from Aywaille to Barvam.

In addition to the excursions heretofore mentioned, during which various methods of road and pavement construction were observed, there were two trips to points

of interest which were undertaken merely for pleasure. The trip to Antwerp upon August 3rd and the trip to the North Sea and Ostend upon August 5th were of this character. Both of these trips were extremely pleasant and added greatly to the enjoyment of the Congress.

Various Belgium municipalities and societies very generously offered receptions and entertainments to the members of the Congress. The first of these occasions was an entertainment upon the evening of July 31st, by the Touring Club of Belgium, consisting of an excellent rendition of M. Emile Verhaeren's drama, "The Cloister." The following morning King Albert of Belgium received the officers of the Congress at the Royal Palace and displayed considerable interest in the work of the association. In the evening the Société Belge des Ingénieurs et des Industriels furnished a musicale for the enjoyment of the members of the Congress. An excellent program was rendered and the occasion was most enjoyable. Upon the evening of August 3rd, the date of the excursion to Antwerp, the Minister of Public Works at Antwerp and the Municipal authorities had a large number of members of the Congress as guests at a brilliant reception. The Congress Banquet, upon the evening of August 6th, was, perhaps, the most enjoyable occasion of this nature during the entire session. The affair was held in the magnificent hall of the "Grande Harmonie," and was well attended. The City of Brussels was not lacking in hospitality, an entertainment being offered August 7th by the Guild of Burgomasters and Aldermen of the City of Brussels. The closing banquet of the Congress was held on the evening of August 10th in the hall of the Municipal Theatre of Namur.

Part II

TECHNICAL DISCUSSIONS

CHAPTER IV

ECONOMICS OF HIGHWAY ENGINEERING

BOULNOIS, H. PERCY, M. Inst. C. E., *Deputy Chief Engineer, Local Government Board,* Whitehall, London, S. W., England, Great Britain.

BREDTSCHNEIDER, AUGUST, *Commissioner of Public Works,* Charlottenburg, Germany.

BRODIE, JOHN A., M. Inst. C. E., *City Engineer,* Liverpool, England, Great Britain.

CATTANEO, PAOLO, *Engineer, Office of Municipal Engineer,* Milan, Italy.

CROMPTON, COL. R. E., M. Inst. C. E., *Royal Automobile Club,* London, England, Great Britain.

EISENLOHR, *Director, Board of Public Works,* Strasburg, Germany.

FLECK, GEORG, *Commissioner, Board of Public Works,* Dresden, Germany.

FLETCHER, AUSTIN B., M. Am. Soc. C. E., *Secretary, Massachusetts Highway Commission,* Boston, Mass., U. S. A.

FORESTIER, J. C. N., *Superintendent, Eastern Division of Parkways,* Paris, France.

FROIDURE, EUGÈNE, *Principal Engineer of Bridges and Roads,* Ypres, Belgium.

HOOKER, S. PERCY, *Chairman, New York Highway Commission,* Albany, N. Y., U. S. A.

HÖRBURGER, *Member, Board of Public Works,* Munich, Germany.

LAFARGA, PROSPERO, *Engineer of Highways, Canals and Harbors,* Alicante, Spain.

LE GAVRIAN, P., *Engineer of Bridges and Roads,* Versailles, France.

LEWIS, NELSON P., M. Am. Soc. C. E., *Chief Engineer, Board of Estimate and Apportionment,* New York, N. Y., U. S. A.

LLOYD DAVIES, D. E., M. Inst. C. E., *Chief Engineer to the Municipality of Alexandria,* Egypt.

MAZEROLLE, L., *Engineer of Bridges and Roads,* Paris, France.

SMITH, J. WALKER, M. Inst. C. E., *City Engineer,* Edinburgh, Scotland, Great Britain.

VERSTRAETE, RICHARD, *Engineer of Bridges and Roads,* Bruges, Belgium.

Belgium. EUGÈNE FROIDURE, and RICHARD VERSTRAETE. The nature of the binding materials to be employed in road construction depends upon climatic conditions. In rainy districts sand, fine river gravel, and granulated porphyry, quartz or hard sandstone, may be used. In dry, hot districts a binding material must not powder, melt or soften. In regions of severe cold, heavy sands, granulated

sandstone, porphyry or quartz, a slow binding mortar of sand and cement, and granulated slag-mortar may be used. In windy districts materials must be adherent like clay, tar, or various mortars of cement and lime.

Egypt. D. E. Lloyd Davies. The climate of Northern Egypt is very favorable to road construction because of its small rainfall and absence from frost. That the roads are practically dustless, notwithstanding a prevalent strong northerly sea breeze, demonstrates the success of the systems adopted. Asphalt is used for the best business quarters, volcanic slag stone pavement for heavy commercial traffic, and tar painted macadam for the main country and suburban roads. The construction of compressed asphalt pavements does not differ materially from the practice in the majority of European cities.

Urine readily attacks the asphalt surface and must not be allowed to accumulate or to remain stagnant for any length of time, but with adequate drainage and careful cleansing, this disadvantage need not be taken into consideration. On iron bridges and other structures subject to vibration, ordinary compressed asphalt fails to give good results. The author has overcome this difficulty by substituting asphalt blocks, subjected to a pressure of 8,532 pounds per square inch, and laid on bituminous concrete in proportions of 58 per cent of mastic asphalt to 45 per cent of silicious stone.

At Alexandria experiments with rock asphalt paving have been carried out. The rock asphalt was crushed to pass through a 4 inch screen and laid $4\frac{3}{4}$ inches thick on a concrete or old macadam base. The surface was then rolled with a roller weighing between 8 and 10 tons. The final thickness of the surfacing was $3\frac{1}{4}$ inches. The result-

ing pavement showed no signs of deterioration at the end of two years, was more elastic than compressed asphalt, and furnished a better foothold for horses.

France. J. C. N. Forestier. The attention of the Congress of 1908 was called to the harmful effect of tar on plants and trees. At that time it was considered especially a question of the action on plants used for floral decoration, because the cellular tissue of such plants is tender. It seemed logical to expect that the same effects would be felt in course of time by shrubs and trees, which are more resistant, and later experience has proved that the harm done to this type of vegetation is unfortunately very great. The writer particularly points to the Avenue du Bois de Boulogne where the formerly most beautiful trees are now all or nearly all in such a condition that fear is being entertained of not being able to effect their recovery and preservation.

At what period and how does the tar act? The first harmful and often very rapid effect takes place at the time of spreading the hot tar. On two occasions in different years on the Boulevard Lannes, at Paris, a border bed of sedium spurium has turned brown on the same day that tarring was done and never regreened. The sophoras and the lime trees, commencing their growth in spring, have appeared tainted by the spreading of hot tar near them, the leaves curling and appearing to be stopped in their development. In order to avoid this disadvantage, which, on recurrence, would cause the death of the plants, it is necessary to proceed with the tarring either before the commencement of the growth of the plants along the roads, or at sufficiently long periods afterwards.

But the dangerous action of the tar is unfortunately

not limited to the vapours of its most volatile constituent parts. The dust raised by intense traffic deposits itself on the plants and, with the slightest sunshine, burns the leaves and buds, and stops the development of the greater part of the trees.

The trees often are unaffected the first and second years, they show fatigue on the third year, and on the fourth they very clearly begin to die. These effects are found along ways of intense traffic, such as the Avenue du Bois de Boulogne at Paris and the Boulevard Maillot at Neuilly-sur-Seine, where in spite of frequent watering the wear of the road surface is such, and the traffic so intense, that between the waterings there is always plenty of dust.

France. P. Le Gavrian. Because of its rapid oxidation and consequent deterioration, certain French engineers do not predict a great future for tar in connection with its use as a road binder. If it be assumed that tar perishes in twelve months and if it is capable of lengthening the life of a road by the same period of time, this fact would be of great importance on roads which have to be remade regularly in two, three or four years, but it would be of less importance on roads subjected to little wear and which last eight, ten or fifteen years when untreated. The uncertainty attending the use of tar on roads draws attention to the asphaltic products which are of more stable character, and with which it may be hoped, even with a doubtless enhanced first cost, more complete and more reliable results may be obtained.

France. L. Mazerolle. The choice of surfacing materials to be adopted for the roadways of a large city depends on a number of considerations, the problem being all the more complex, since the choice may concern materials

of very varied natures, and, since the number of cases where the advantages and disadvantages of the methods in use appear to contradict one another are very frequent. We should not, therefore, attempt to fix invariable rules leading to mathematical conclusions.

The cost of construction and maintenance is not usually, in large cities, the determining factor which influences the selection of surfacing materials. In Paris the unit costs of maintenance of macadam, asphalt pavement, wood pavement, and stone block pavement are relatively in the order here given, macadam being the most costly and stone block pavement being the least costly. The actual cost of maintenance for a given surface is difficult to state because of the varying standards of excellence in the surface which different localities intend to maintain.

The nature of the traffic is of prime importance in the maintenance of the roads, and it would be very interesting to be able to represent it in figures proportional to its destructive character.

Noiselessness is an essential consideration in connection with city streets, especially in the vicinity of schools, hospitals and other public buildings. Macadam and wood pavement have very nearly the same degree of noisiness. Stone block pavement is the noisiest type of pavement. On asphalt pavements the noise of wheels is insignificant compared to the noise from horses' hoofs.

It is necessary to distinguish between the transported dust due to horse droppings, to earth and gravel escaping from carts, to building construction, to mud carried along by traffic, to refuse from riparian dwellers or the passers-by, etc., and the dust due to the wear of the roadway or from the repairs required for its maintenance. The nature of

the road surface will obviously have no influence on the dust arising from the causes of the first category, but the road surface on the other hand has to accommodate itself to the influences of dust. Only wood pavement appears somewhat affected in this respect, a faulty cleansing and a prolonged contact of mud with it being disastrous. Macadam roads have the greatest tendency to produce dust. Next in order come stone block pavements. Wood pavements and asphalt pavements produce in themselves little dust, but the application of sand or gravel to prevent slipperiness in wet weather often creates a source of dust.

Slipperiness is much more to be feared when the surface is smooth and in consequence more perfect in regard to other features. The chances of slipping increase with the gradient in such a manner that slipperiness and gradient should be simultaneously examined. Compressed asphalt is apt to become slippery, especially in wet weather. When the slope of a road exceeds 1.5 per cent, asphalt is not used. Some kinds of stone are slippery when made into stone blocks, porphyry having been given up in Paris for this reason. Wood pavement is not slippery when it is clean. In Paris wood blocks are used on gradients up to 5 per cent.

It is essential to be able to repair a road surface without causing too great a nuisance to traffic. In the case of macadam roads, Paris is gradually giving up the system of maintenance called partial repairs for the more satisfactory method of complete resurfacing. It is considered a better scheme to block the road a few days entirely rather than to make poor repairs. Stone block pavements are readily repaired without delay, while the repair of wood block pavements necessitates a slight delay in order to allow

the cement in the joints time to set. Where it is especially desired to reduce the delay incident to repair of wood block pavements, a heavy coat of sand is put on to deaden the shock, but this method is not very satisfactory.

Experiments have shown that all rails of tramways undergo a deflection upon the passage of tramcars. Hence a separation between rail and road surface is inevitable. The tendency of vehicles to keep two wheels on a track is injurious in disturbing the surface close to the rail and also in forming a path the width of the gauge of the vehicles from the rails. Stone metalling is altogether unacceptable for the rail areas of urban tramways. Asphalt pavement proves unsatisfactory next to the rails, and repairs are costly. The experiment of placing an elastic layer of poured bitumen between the rail and the asphalt has not been found satisfactory. Wood pavement gives very good results next to rails where the rails are on a firm concrete base. The maintenance, however, is rather costly, especially when the wood has to be freed from sap in order to remedy the nuisance arising from creeping. Stone block pavement seems to suffer least next to rails, but this is due in part to the fact that the surface is naturally rather irregular and the public is consequently less exacting with regard to it.

From the point of view of hygiene the best road surfacing material is the one which, having no joints whatever, does not absorb the liquids falling on the roadway. Compressed asphalt is theoretically the best road surfacing from this standpoint. Stone block pavements seem subject to criticism because of the apparent infiltration of water through the sand joints. This infiltration is frequently found very slight where old pavements are removed. Wood

pavements are often accused of absorbing filthy liquids, but experiments carried out at Paris refute this theory. Altogether it appears that public health is less affected by the nature of the material constituting the road surface than by the quantity of dust produced and by the extent to which cleaning operations are carried out.

On roads in good state of repair the resistance to wheels appears to be very little dependent upon the nature of the road surface. This doubtless explains why, since the celebrated experiments of General Morin, the question has been relatively little studied, at least in France.

Macadam costs between $1.13 and $1.45 per square yard according to whether millstone grit or porphyry is used. The cost of maintenance reaches 36 cents per year in certain instances. Tar treatment of macadam roads has increased very extensively in recent years, the labor being done by city workmen at a cost of about 2½ cents per square yard. The tar treatment of roads has, on some streets with heavy traffic, lasted only a very short time, while in other cases better results have been secured. In spite of the recent improvements in macadam construction, it seems that, from all points of view, macadamizing should not be prescribed for urban roads of any importance.

The first cost of construction of a square yard of stone block pavement varies between $2.83 and $3.53. The maintenance is about 13 cents per square yard per year. Laying the blocks directly on concrete has been given up because of the lack of elasticity. Trials with cement or tar in the joints have not been developed. The rolling of stone blocks has been tried and found inferior to tamping by an experienced paver. The chief fault of stone block pavement is its noise, and it is for this reason

that it is disappearing on all first class streets with intense traffic.

The average cost of constructing a square yard of asphalt pavement 2 inches thick is from $2.87 to $3.18, including the concrete foundations. The Rogusa rock (Sicily), Val de Travers, Seyssel, and lately Saint Jean de Maruejol rock have been used. No precise rule appears to exist relative to the choice of powder and the proportion of bitumen dependent upon the position of the street, in spite of the importance which is attached to these precautions in other countries. American asphalt, a mixture of silicious sand and bitumen, has been tried and has proved satisfactory. It appears less slippery and less liable to peel. Asphalt macadam has been tried in several places in Paris with varying success.

One trial of asphalt blocks had been attempted, and another trial was about to be undertaken at the time of writing this report. The elimination of the transportation of hot powder and the fact that no compression is necessary recommended this form of paving over ordinary asphalt pavements. It appears on account of its brittleness, however, not to be suitable for streets of excessively heavy traffic.

The first cost of construction of a square yard of pavement of wood, including the foundation, varies according to the kind of roadway from $2.82 to $3.06. The maintenance may be kept under 16 cents per square yard per annum.

Germany. AUGUST BREDTSCHNEIDER; HÖRBURGER; EISENLOHR; and GEORG FLECK. The percentage of macadam surface to the total street area even within a city's limits varies inversely as the number of inhabitants. Macadam surface is found to the extent of 44.9 per cent of

the road surface in some small towns, while in Greater Berlin only 2 per cent is found. This form of surface is the cheapest in Germany and is suitable for streets of light traffic.

Great Britain. H. PERCY BOULNOIS. In England the money lent by the Local Government Board for the construction of ordinary macadam roads has to be repaid in five years. If, however, the road is constructed with tar macadam, the term of repayment is extended to ten years, which shows that the Board considers that the life of the road is doubled by the adoption of this type of construction.

Great Britain. JOHN A. BRODIE. The writer is in charge of the administration of a number of roads representing the most varied conditions, and his personal experience leads him to this deduction, that it is not possible to condemn either ordinary macadam or macadam constructed with some bituminous material. The choice of surfacing material is not so much a question of whether the road is located within or without the city as it is a question of the traffic. If the traffic is very slight ordinary macadam or macadam with a superficial coat of tar may be perfectly satisfactory: with a traffic of 80,000 tons per annum per yard of width, macadam incorporated with a bituminous material gives the best results, especially where a noiseless pavement is desired; in the case of a traffic up to 400,000 tons per annum per yard of width, stone block pavement of the very best quality is necessary. It is, therefore, desirable to subdivide the streets into classes according to their traffic.

Great Britain. COL. R. E. CROMPTON. It has been only within a few years that macadam roads have

given satisfaction in England. The development of tarring is responsible for this new status of the macadam surface.

To insure success in any tarring operation it is necessary to adopt the following precautions: a careful selection of the bituminous material; a careful study of the road metal as to its capacity to absorb the tar; a study of the heat radiating properties of the road materials, as affecting the deposition of hoar frost on the surface and consequent slipperiness; and finally the application of the minimum quantity of tar which will effectually waterproof the surface, an excess of tar remaining fluid within the road allowing by its lubricating action the movement of the stones among themselves.

In London and Liverpool stone block pavement is only adopted for streets in the vicinity of the docks where the traffic attains a million tons per annum per yard width of roadway. For some time, however, a more silent and elastic form of surfacing, obtained by the use of some bituminous material with broken stone, has been substituted for stone block pavement in many places.

Great Britain. J. Walker Smith. The method of construction to be employed depends upon local circumstances. A superficial coat of tar on an ordinary macadam road which can be applied at a cost of 2 cents per square yard may be satisfactory under certain conditions. On the other hand conditions may require the construction of a bituminous pavement built by the mixing method at a cost of $1.25 per square yard. There are several methods of construction, the cost of which lies between 2 cents and $1.25 per square yard, with which it is possible to meet almost any conditions.

Italy. Paolo Cattaneo. The most commonly constructed pavements in Italy for streets of very heavy traffic are the asphalt pavement and the stone block pavement.

Stone block pavements are constructed of blocks of granite, porphyry, syenite, or sandstone. For streets of steep gradient, granite is the most suitable material because of the good foothold allowed. As was stated by the reporting officers from Hungary to be the case in that country, the system of laying the blocks diagonal to the direction of traffic is preferred also in Italy. Concrete foundations are not extensively used, a well constructed sand foundation being preferred.

The asphalt used for the construction of asphalt pavement is mined in Italy. The form of construction is the so-called tamped asphalt pavement, which is powdered rock asphalt heated and tamped into place.

Wood block pavements have not found much favor in Italy.

The trials made in Italy with tarring macadam surfaces or with tar macadam pavements have not given results favorable enough to enable one to recommend the adoption of either method on an extensive scale. It must be admitted, however, that a great stride has already been made towards the solution of the dust problem, a problem which is of great interest to all who study sanitation and at the same time questions of cost.

Macadam surfaces, as a transitional method, are certainly appropriate for roads in towns whose financial position does not allow them to adopt more permanent and more expensive systems.

Spain. Prospero Lafarga. City pavements should possess high durability, should be capable of being repaired

without interfering with traffic to too great extent, and should not be excessively productive of dust. The pollution of the subsoil is an important element to be considered in those towns whose sewers are in poor condition as regards imperviousness. It is advisable to have in such localities pavements which will allow the escape of emanations from the subsoil.

United States. Austin B. Fletcher. In Massachusetts it is estimated that the maintenance charge of state highways has increased from 1.14 cents to 5.7 cents per square yard per annum in the last three years. Although it is true that many of these highways were nearing a time when they would require resurfacing, this need for resurfacing was hastened and aggravated by the motor vehicles. An estimate made before motor vehicles became so numerous indicated that about 2.25 cents per square yard per annum would be needed for the proper maintenance of the highways. It seems fair therefore to place the bulk of this extra cost on the increased auto traffic and the increased speed at which the motor vehicles are driven. From 1903 to 1909 the number of motor vehicles registered in Massachusetts has increased from 3,241 to 23,902. In 1903 only 14 per cent of the motor vehicles were more than 10 horse-power, while in 1908, 78 per cent were in excess of 10 horse-power.

United States. S. Percy Hooker. Patrol sections five to eight miles in length have been established by the Commission. Along each stretch is placed a pile of stone of two sizes, ¾ inches to 1¼ inches and 1¼ inches to 2¼ inches. Each patrolman supplies a horse and cart and carries a barrel of water, or bituminous material, if the road has been treated with the latter. Whenever a rut is found

the patrolman fills it with ¾ inch stone. It has been found that on a road which has not been treated with a bituminous material, and where the motor traffic does not exceed 30 per cent of the entire traffic, that the average quantity of stone used by the patrolman will be approximately 25 cubic yards per mile. By properly repairing the ruts and other depressions in the surface and by the constant brushing back of the screenings, which are displaced by the traffic, to the center of the road, it has been possible to maintain many of the ordinary macadam roads in an excellent condition.

United States. NELSON P. LEWIS. Two years ago the writer did not feel disposed to plead for the recognition of macadam as a suitable material for anything but country roads, or possibly for little used and unimportant city streets. During the two years which have elapsed since the First Congress, however, there has been a great improvement in the method of building macadam roads. This improvement, through the use of bituminous binding material, has added so little to the cost of this kind of pavement that it still remains the cheapest form of road surface which will meet the requirements of modern traffic.

CHAPTER V

TRAFFIC CENSUS

FLETCHER, AUSTIN B., M. Am. Soc. C. E., *Secretary, Massachusetts Highway Commission,* Boston, Mass., U. S. A.

GUÉCHOFF, STÉFAN CHR., *Director-General of Highways,* Sofia, Bulgaria.

MOULLÉ, A., *Chief, Division of Highways and Bridges, Ministry of Public Works,* Paris, France.

VANDONE, ITALO, *Chief Engineer, Province of Milan,* Italy.

Bulgaria. STÉFAN CHR. GUÉCHOFF. There has been but one traffic census carried out in Bulgaria. This census was taken during the entire year from Oct. 1st, 1896, to Sept. 31st, 1897. Observations were taken on a length of 2,251 miles of National Roads at 208 posts. Counting was done every day without exception, and night counting was carried on each night at some posts, on all but rainy nights at others, and twice each week on different nights at other posts.

The following items of traffic were separately noted: loaded farm wagons; empty farm wagons and sundry light vehicles; loaded beasts of burden; unloaded beasts of burden and animals with riders; large cattle; small cattle. As in the French system, a unit was selected for the reduction of all other types of traffic. Since cattle were in general use as draft animals, the "yoke," a wagon drawn by a yoke

of oxen, was chosen as this unit. Coefficients of reduction were applied to each category of traffic and the total result expressed in "yokes."

The gross and the useful tonnage was also arrived at by estimates of the weights of the various classes of traffic, an estimate easily made because of the limited nature of the kinds of traffic.

The writer feels confident that results fully as satisfactory might have been arrived at by limiting the number of observing days to about ten days in each quarter of the year.

France. A. Moullé. Ten censuses of traffic over the entire country have been undertaken by the Department of Bridges and Roads. The intervals between the taking of these comprehensive data have varied from five to nine years. The first census of national scope was taken in 1844, although previous to that time traffic data had been collected in certain localities. Traffic censuses of national character will in the future be undertaken every ten years.

Previous to the advent of the motor car the categories of traffic noted underwent little change. Five divisions were recognized; first, freight vehicles and those for agricultural purposes when loaded; second, public vehicles for common transport of travellers and luggage; third, empty freight or agricultural carts and private carriages; fourth, unharnessed animals of large size; fifth, light live stock. Until the census of 1903 this classification was considered sufficient, but the increase in the amount of motor car traffic necessitated separate classification of this type of vehicle. Five categories are here also recognized: first, motor vehicles with metal tires, which are usually heavily loaded; second, motor cycles; third, vehicles with

elastic tires capable of travelling thirty miles an hour and compelled by law to have a registration number attached; fourth, vehicles with elastic tires which cannot attain this speed; fifth, cycles.

Coefficients of reduction are applied to each division of classification of both groups of traffic so that totals may be expressed in comparable units. The unit adopted is known as a "collar," and is described as a traction animal harnessed to a loaded vehicle. The coefficients of reduction employed are given in the following table:

1. Vehicles loaded with produce or merchandise, and public conveyances for travellers	1
2. Empty or private vehicles	$\frac{1}{2}$
3. Unharnessed animals	$\frac{1}{3}$
4. Light live stock	$\frac{1}{30}$
5. Motor cars with metal tires or traction engines	$\frac{\text{Wt. in tons}}{0.284}$
6. Motor cycle	0.3
7. Motor car with number	3.0
8. Motor car without number	1.0
9. Cycle	0.05

The tonnage is estimated as the weight transported. It is impossible to weigh on scales all the different types of vehicles, but by means of a sufficiently large number of actual weighings, and information gathered from the principal transport agents, the average weight which a collar of each category on each section of the road draws is ascertained.

Tonnage is divided into "useful tonnage" and "gross tonnage." The gross tonnage includes everything that is drawn, while the useful tonnage covers only the load carried by the vehicles. The weight of persons was in the earlier census considered as useful tonnage, but, since 1882, this has not been the case.

The importance of a census of tramway traffic in connection with a census of highway traffic has been recognized for a number of years. The usual method employed is to secure such data from the companies that operate the tramways. It has been recognized that the influence exerted by the tramways on the wear and tear of roads is in no wise a function of the traffic intensity, but that it depends more especially on the position of the rails in the road and the width of the area which remains entirely free beyond the rails for ordinary traffic.

The census is taken in the following manner: the roads are divided into a certain number of sections, in each of which it is assumed that the traffic is more or less constant from one end to the other. At one point of the section, chosen as the point of observation, an observer notes on a printed form the vehicles and animals of each category which pass in front of him. The choice of the points of observation is of the utmost importance. For purposes of comparison of the censuses it is essential to have the points of observation the same in each case unless changed conditions make it absolutely necessary to shift. For a maximum of exactitude it would be necessary to divide a road into as many sections as there are branch roads, but this is of course impracticable. It is very important to have conscientious observers. Roadmen are usually employed for the purpose in France.

The census is taken over the entire year, but it is too expensive to take it each day in the year. The method considered as the most practicable, from the standpoint of the elimination of undue effect of abnormal traffic upon the average result, is to take count upon single days at regular intervals. The last two censuses have been taken upon

single days at a constant interval of thirteen days. Counting at night is done occasionally upon each section at such times as the engineer sees fit. It is usually desired to take at least one night count in each of the four seasons of the year.

Italy. ITALO VANDONE. No comprehensive traffic census over the entire country has ever been taken. The interest in the matter of such statistics is of recent development, although isolated instances are on record of traffic data having been secured at earlier dates. The methods employed in the various provinces vary somewhat, owing doubtless to variable conditions.

In the census carried out near Milan sixty-three posts were established at thirteen of which two chief roadmen observed the traffic, by day and by night without interruption, for seven consecutive days each season, or for twenty-eight days of twenty-four hours in the year. They were provided with a tent, lanterns, fires, folding chairs, etc. At the other fifty posts two roadmen were placed, generally those of the nearest road district, who made observations by day for seven consecutive days each season, or for twenty-eight days of twelve hours in the year. These posts were equipped in the same manner as above mentioned. The census outside Milan extended over 1908 and 1909.

The general method of classification and reduction to units was the same as the French system, the French "collar" being employed, although the coefficients of reduction varied somewhat from the French usage.

An estimate of tonnage was secured by determining upon the average weights of the various classifications of traffic. These average weights were secured by averaging frequent observations of the weights of various types of vehicles by the observing officers.

As to night traffic, the writer considers that the ratio of night traffic to day traffic might be obtained and this ratio applied for a number of years without any actual night census being necessary.

A census similar to the one at Milan was carried out in the province of Modena from 1901 to 1904. Each year twenty-eight observations were made, one being taken at each station every thirteen days. Half of the observations were made for the total twenty-four hours, that is, once every twenty-six days. There were two overseers at every post with a total of sixty-four roadmen and twenty-four assistant workmen.

United States. AUSTIN B. FLETCHER. A traffic census was made by the Commission on some of the State Highways during August and October, 1909. Over 235 stations were established at which the traffic was observed.

The following table shows the results obtained:

TOTAL NUMBER OF VEHICLES PER DAY OF FOURTEEN HOURS.

	HORSE DRAWN			AUTOMOBILE*			Total all Kinds
	Light	Heavy	Total	Runabouts	Touring Cars	Total	
August.......	19,622	17,969	37,591	5,922	21,387	27,309	64,900
October.......	16,456	17,967	34,423	3,995	14,514	18,509	52,952

AVERAGES PER DAY PER OBSERVER'S STATION.

	HORSE DRAWN			AUTOMOBILE*			Total all Kinds
	Light	Heavy	Total	Runabouts	Touring Cars	Total	
Aug. (237 stations)..	83	76	159	25	90	115	274
Oct. (240 stations)..	69	75	144	17	60	77	221

* Motor cycles not included.

CHAPTER VI

MATERIALS OF HIGHWAY ENGINEERING

BREDTSCHNEIDER, AUGUST, *Commissioner of Public Works*, Charlottenburg, Germany.

CAMERMAN, EMILE, *Engineer*, Brussels, Belgium.

CORNU, LOUIS, *Principal Engineer of Bridges and Roads*, Arlon, Belgium.

CROSBY, WALTER W., M. Am. Soc. C. E., *Chief Engineer to Maryland Geological and Economic Survey*, Baltimore, Maryland, U. S. A.

HENNING, JOHN, *Imperial Commissioner of Public Works*, Oberlahnstein-on-the-Rhine, Germany.

HUBBARD, PRÉVOST, *Chemist, Office of Public Roads*, Washington, D. C., U. S. A.

LLOYD DAVIES, D. E., M. Inst. C. E., *Chief Engineer to the Municipality of Alexandria*, Egypt.

MESNAGER, AUGUSTIN, *Chief Engineer of Bridges and Roads*, Paris, France.

MIKHAÏLOFF, PAUL, *Engineer of Highways*, St. Petersburg, Russia.

TOURING CLUB OF ITALY, Italy.

TSVÉTKOVSKY, CONSTANTIN, *Engineer of Highways*, Warsaw, Russia.

VAN LÖBEN SELS, M. J., *Vice-President, Netherlands Association of Brick Manufacturers*, Nimwegen, Netherlands.

WALBAUM, LUDWIG, *Imperial Commissioner of Public Works*, Gratz, Austria.

Austria. Ludwig Walbaum. Except in a few special cases where traffic necessitates paving, the roads of Styria are macadamized. The material usually employed is limestone, although graywacke, serpentine, horn-slate, eclogite, trachyte and basaltic rocks are also used.

The stone must have power to resist abrasion, should have a small capacity for absorption and should possess strong binding power. The tests of stone in Styria are usually confined to the determination of absolute strength, which test in itself often gives unsatisfactory results.

A study of the grain of material for ordinary metalled roads is important as influencing the form of fracture. A stone whose tendency is to break into splinters or flat slabs is not satisfactory. Material of uniform polygonal form is the best for construction work. As a rule stone broken by hand gives better results in this respect than stone broken by stone crushers. The mechanical methods at present employed may be improved to secure stone of better quality. Owing to the round holes in a crusher screen, long, flat stones may pass through readily. The writer suggests the use of a secondary screen with bars of triangular cross-section forming long slots through which flat stones may pass and be collected in a separate bin. These flat stones may be recrushed later after the gauge of the jaws of the crusher has been narrowed.

Belgium. Louis Cornu and Emile Camerman. The top course of a macadamized road is subjected by the action of wheels to crushing forces, to internal friction, to surface friction, and to blows more or less severe according to the unevenness of the road. The action of horses' hoofs produces friction and a chipping effect. Owing to exposure on the surface of the ground, the stone is subjected to frost

action and to the corroding influence of rainwater charged with various impurities absorbed.

In order to resist the influences mentioned above the stone employed should be tenacious, elastic, frost proof, only slightly porous, immune from attacks of acids and alkalies and homogeneous. In order to satisfy other requirements not mentioned above the road metal should not be capable of receiving a polish as a result of the traffic. It would, therefore, be advisable to submit the materials to the following tests and examinations before approval is given, if it is desired to ascertain to what extent each sample possesses all the requisite qualities:

1. Chemical analysis, qualitative and quantitative.
2. Resistance to compression.
3. Resistance to concussion.
4. Resistance to wear.
5. Resistance to alternate freezing and thawing
6. Resistance to the action of acid solutions.
7. Resistance to the action of alkaline solutions.
8. Specific gravity.
9. Porosity.
10. Amount of polish in wear.
11. Homogeneity.

The writer is of the opinion that it is not possible, without the help of practical experience, to make a judicious choice of materials to be used from the consideration of the results of laboratory analysis. The investigation of old road materials to see whether or not they have proved satisfactory is important. The same tests should be made of the old materials as are made of materials to be used, and in addition it is exceedingly important to note the nature of

traffic over the road, nature of soil, the climate, conditions of exposure, gradient of the road, cross-section of the road, original dimensions of the material and place from which the material originally was obtained. It is also important to note the degree of satisfaction the road has given from the standpoint of slipperiness, muddiness, dustiness and noisiness. Information as to the amount of sweeping, watering, tarring and scraping employed should also be secured.

In the investigation of wood blocks, chemical analysis is valueless, but timber should be examined as to its age when felled, its texture, its compactness, its closeness of grain, its general soundness and such physical or mechanical properties of wood blocks as specific gravity, resistance to frictional wear, resistance to crushing, resistance to blows, elasticity, and hygroscopic properties should be ascertained.

The principal qualities which rock asphalt for asphalt pavements should possess are the following:

1. Small amount of sand, as this substance is not well adapted to compression.
2. Small proportion of clay, as this substance is apt to cause swelling in damp weather and shrinkage in dry weather.
3. Absence of pyrites, a substance which is transformed by heat into unstable sulphides which, in their turn by oxidation, are changed into soluble sulphates and may cause the rapid deterioration of the surface.
4. The asphalt powder used in making compressed asphalt should contain six to thirteen per cent of bitumen.
5. Homogeneity.

All of these qualities except the last can be verified by chemical analysis.

The following test by Durand Clayé is recommended for detection of coal tar pitch in asphaltic compounds: the asphalt is well broken up and treated with carbon bisulphide. The liquid, which contains the dissolved bituminous matter, is filtered and the filtered material is evaporated until all of the carbon bisulphide has disappeared, after which it is heated until the bituminous mass has hardened. This is detached from the bottom of the receptacle and is reduced to fine powder. One-tenth of a grain of this powder is treated with 5 cubic centimeters of concentrated sulphuric acid and allowed to soak for twenty-four hours. Ten cubic centimeters of water are then carefully added and the mixture stirred. The water is allowed to act for some minutes after which the mixture is filtered and washed with 100 cubic centimeters of water. When the asphalt is pure, the filtrate is colorless; but if any coal tar pitch has been added, the filtrate will vary in color from light brown to black, according to the amount of pitch which has been added. The best materials, whose use may be tolerated in order to add fluidity to molten asphalt, are Trinidad bitumen and the fluid pitch of mineral oil. They should stand the following test: namely, that a drop allowed to fall on blotting paper should preserve its shape without spreading into a circular patch, even in three days.

Egypt. D. E. Lloyd Davies. Macadam road construction in Alexandria has been very successful, the stone used being basalt of the middle tertiary age. It is a finely crystalline volcanic rock, the constituent minerals being chiefly feldspar, augite, olivine and magnetite. The stone is very hard and tough, and great difficulty was at first experienced in finding a suitable binding material, both silicious and calcareous sand proving useless for the purpose.

After many experiments with different substances the reddish colored earth locally known as tina was tried, and the result was so favorable that it has been universally adopted. The following is an analysis of the tina kindly supplied by my colleague, Dr. Dotschlich, from the Chemical Department of the Public Health Service:

Sand	66.70	per cent.
Clay	9.98	"
Humic substances	1.23	"
Earthy carbonates (calculated as $CaCO_3$)	17.31	"
Water	3.50	"
Soluble substances and loss	1.28	"

France. AUGUSTIN MESNAGER. In order to determine the resistance of stone blocks to wear by friction the general practice is to use a sanded friction plate. The sand for this use is obtained by crushing a quartz sandstone from a certain locality and screening the resulting sand to a uniform size. The plate, loaded with 250 grams per square yard and covered uniformly with sand, revolves at a rate of 2,000 revolutions per hour. Each end of the test piece is subjected to 2,000 revolutions, and the diminution of height at each end is measured.

In order to test the resistance of stone blocks to blows of horses' hoofs and wheels of vehicles the Laboratory of the School of Bridges and Roads employs a drop-weight machine. A weight of 4.5 kilograms falls from a height of 1 meter upon a cubical specimen of 4 centimeters edge length. The number of times the weight fails to create complete fracture is an indication of the strength of the block.

The only test for metalling material which will be

described is the test for resistance to internal friction. This experiment, as carried out at the Laboratory of the School of Bridges and Roads, is as follows: 5 kilograms of broken stone fragments, selected so that there are few or no sharp edges, are placed in cylinders which are revolved about a horizontal axle to which they are inclined at an angle of 30 degrees. The cylinders are revolved at a speed of 2,000 revolutions per hour for a total of 10,000 revolutions, and the dust under 0.16 of a centimeter in diameter is carefully collected and weighed. The coefficient representing the quality of a material is computed by the formula $Q = \frac{400}{U}$ where U is weight in grams of dust under 0.16 of a centimeter in diameter per kilogram of material.

Germany. August Bredtschneider. The methods for analyzing rock asphalt as employed in Germany, are as follows:

A. Analysis of the asphalt powder.

1. The quantity of bitumen soluble in chloroform is found by pouring chloroform over the powder until there is no discoloration of the liquid, and then drying and weighing the residue remaining.

2. The insoluble constituents of bitumen, silica and alumina are determined by pouring hydrochloric acid over the powder left from test number 1. By drying and incinerating this powder the SiO_2 is found. The difference in weights before and after incineration gives the quantity of insoluble bitumen. By finding the percentage of ferric oxide and alumina the quantity of clay may be calculated.

3. The carbonate of lime is found by determining the

quantity of carbonic acid (CO_2), formed by the application of hydrochloric acid to the asphalt.

4. The specific gravity of the powder is found by weighing a certain volume of the asphalt powder ten times and comparing the average of these weights with the weight of the same volume of water.

B. Analysis of the bitumen.

1. The specific gravity is determined by comparison with the weight of an equal volume of water.

2. The melting point is found by finding the temperature at which a sheet of bitumen 5 to 10 millimeters in thickness is penetrated by 5 grams of quicksilver.

3. The dripping point is found by measuring the temperature at which a drop falls through a hole 3 millimeters in diameter by its own weight.

4. The percentage of sulphur is determined by burning in oxygen and measuring the quantity of sulphuric acid formed. From this percentage the percentage of sulphur may be computed.

C. Determination of geological characteristics.

Microscopic tests are of great value in checking statements by manufacturers as to the origin of their asphalts. Shells and other animal matter present may readily be discerned by examining a polished sheet of asphalt of extreme thinness.

Germany. John Henning. We have used in Germany a slag which contains a slight quantity of silica and lime and which is a product of the lead works at the Lahn deposits. This slag does not contain 40 per cent of siliceous

and lime substances as does that of blast furnaces, but only 16 to 20 per cent of lime and 28 to 30 per cent of silicates. Its other constituents are 35 to 40 per cent of iron, 6 to 8 per cent of zinc and up to 30 per cent of sulphur. The effect of sulphur in the slag is harmful. Compared with a metalling of tarred basalt, this surfacing of tarred lead slag is very satisfactory.

The use of asphaltic products, oil and petroleum residues, is scarcely known at all in Germany. Coke oven tar which is extensively produced in this country is used almost altogether for the bituminous material. In the construction of the bituminous pavements, the writer believes that preference should be given to the tar which has a small free carbon content.

Italy. Touring Club of Italy. Although laboratory experiments may be thought indispensable for a complete knowledge of metalling materials, they are, however, not sufficient to define the coefficient of quality of such material. Because of the fact that laboratory tests are made separately for each cause of wear they cannot reproduce the wear and tear on a highway as it really is produced by the principal causes of deterioration, such as traffic, atmospheric effects, the special and various conditions of subsoil, exposure, grade, width of the road, etc.

It is advisable to investigate the adaptability of various materials of predetermined characteristics for various conditions of traffic and climate by employing these materials under conditions of widely differing character and keeping accurate records of the adaptability of the materials in each case.

It is desirable that experiments should be carried out with the object of inventing a machine capable of reproduc-

ing in a laboratory the construction of an artificial macadam road and its wear and tear by traffic. If, for each material thus tried, a constant relation could be ascertained between results thus obtained and those obtained by comparative trials on the highway itself, there would be reason to attribute great importance to the results obtained by this machine in estimating the coefficients of quality of metalling material.

It will be well to study whether from the comparison of the results of different laboratory trials with those of road experiments it is possible to deduce a synthetic relation between the combination of the physical, chemical and mechanical properties of any given material and its coefficient of quality determined in the manner described.

Netherlands. M. J. Van Löben Sels. The gravel of Holland is not of a hard nature. The roads constructed with gravel have a tendency to rut besides being very dusty and muddy. By building a track of brick in the centre of the road for horses to tread on and having the remainder of the road gravel gives very good results.

Nearly two-thirds of the State Roads are built of brick, giving excellent results. The usual dimensions are approximately 2 inches by 8½ inches. In South Holland bricks 2 inches by 3½ inches by 7 inches are employed. Bricks must be sound to prevent chipping, hard to resist horses' hoofs, not deformed in any way, and laid on a rolled bed of sand.

Russia. Paul Mikhaïloff, and Constantin Tsvétkovsky. Vitrified bricks, owing to lack of suitable road metalling materials, and the excellent results attained, are extensively used. The State owns the vitrified brick manufacturing establishments and employs the brick only

on State Roads. A chemical analysis of the clay at one of the works gave the following results:

Silica, free	69.60	per cent.
Silica, combined	10.51	"
Alumina	8.70	"
Ferric Oxide	3.04	"
Lime	0.85	"
Carbonic Acid	0.71	"
Magnesia Oxide	0.77	"
Water	5.70	"
Total	99.88	per cent.

Poor quality bricks are crushed and used for macadam construction.

United States. WALTER W. CROSBY. Bituminous binders must, first of all, bind. Their power to adhere to the road metal must be of the highest. Their adhesive ability must, if not equal to their cohesive strength, at least be sufficient for the purposes of their application and *vice versa.* Consequently, such a test as the ductility test, which measures the ability of the material to elongate without rupture, seems insufficient to determine the true binding ability of a material, and a better test should be devised.

Bituminous materials should be fluid in the technical sense of the term. That is, they must impart to the road surface a self-healing ability and must, as far as practicable, be so far from being brittle as to successfully resist the shocks of ironshod traffic even in the coldest and most hostile weather. Again, when successful under cold weather conditions as regards resistance to shocks, they must not

become so fluid under warm weather conditions as to become displaced from their proper position in the road surface.

They should be, in regard to these characteristics, as stable as possible under the conditions of their use. If fluxed to meet local or particular conditions, the base should still be of a character which will preserve the above characteristics, notwithstanding the temporary presence of the flux.

A desirable bituminous binder should combine the above characteristics with the least practicable admixture of useless or possibly obnoxious adulterants.

In the table are tabulated tests of different bituminous materials used by the writer in some experimental pieces of road built under his direction during 1909 and 1910.

United States. Prévost Hubbard. When making an examination of bituminous materials, a number of factors should be considered, which may often modify to some extent the method to be employed. Those of most importance are as follows:

1. Purpose for which the material is to be used; for instance, as a dust preventive only, as a semi-permanent binder and dust preventive for surface treatment, or as a permanent binder in construction work.

2. Character of the road to be treated, including the type of road (earth, gravel, or broken stone), and the physical characteristics of the road material.

3. Desired method of application; namely, whether the material is to be applied cold or hot, by means of a distributor with or without pressure, by pouring from buckets, or as a prepared mixture with the road material.

TABLE SHOWING ANALYSIS OF BITUMINOUS MATERIALS USED IN

ANALYSIS	1 (5)	2 (2)	3 (2)	4 (1)	
Water soluble Material	None	None	None	None	
Free Carbon, insoluble in Carbon Bi-Sulphide	Trace (1) 0.14% (4)	0.24%	2.96%	0.066%	
Insoluble in Carbon Tetra-Chloride	0.129%	0.33%	4.525%	....	..
Ash	Trace (4) 0.20% (1)	Trace (1) 0.56%(1)	8.12%	0.05%	
Fixed Carbon less Free Carbon	7.17%	5.46%	5.51%	25.55%	2
Specific Gravity	0.9551	0.9788	1.075	1.202	
Viscosity at 100° C. Engler	349 Sec.	150 Sec.	990 Sec.	302 Sec.	14
Lunge Tar tester at 100° C	....	....	9 Sec.	....	..
Lunge Tar tester at 25° C. reading to 1.4°	Too hard (1) 86 Sec. (4)	36 Sec.	473 Sec.	358 Sec.	75
Loss on evaporation at 105° C. 21 hrs. 3½″ dish	12.5%	1.85%	7%	9.5%	1
Penetration of this residue at 4° C	59.1	Too soft	16	Too hard	T
Penetration of this residue at 25° C	Too soft (1) 130 (4)	Too soft	62.5	13	2
Melting point of this residue	39.6° C.	Too soft	48° C.	58° C.	5
Loss on evaporation at 170° C. 2½″ dish. 3 hrs.	14.1%	2.8%	14.75%	17.5%	1
Loss on evaporation at 170° C. 2½″ dish. 5 hrs.	16.6%	3.81%	17.5%	22%	2
Penetration of this residue at 4° C	Too hard (1) 35 (4)	214 (1) Too soft (1)	6.5	Too hard	T
Penetration of this residue at 25° C	Too hard (1) Too soft (1) 116 (3)	Too soft	17.5	Too hard	T
Melting point of this residue	50° C.	Too soft	72.5° C.	79° C.	8
Loss on evaporation at 205° C. 3 hrs	25.25%	4.22%	21.75%	26%	2
Loss on evaporation at 205° C. 5 hrs	28.2%	6.35%	27%	29%	3
Penetration of this residue at 4° C	Too hard (1) 23 (4)	146 (1) Too soft	2	Too hard	T
Penetration of this residue at 25° C	Too hard (1) 74.5 (4)	Too soft	6.50	Too hard	T
Melting point of this residue	69.2° C.	8° C. (1) Too soft	87.5° C.	87° C.	9
Paraffine Scale	0.94%	0.42%	0.49%	....	..
Solubility in 88° Naphtha	77%	93.9%	69.95%	....	..
Character of residue when evaporated on glass	Sticky	Sticky	Sticky	....	..
Initial temperature of Distillate	....	....	....	214° C.	21
Room temperature to 105° C	....	....	....	None	N 0
105° C. to 170° C	....	....	....	None	
170° C. to 225° C	....	....	....	3%	0 1
225° C. to 270° C	....	....	....	3%	2
270° C. to 300° C	....	....	....	10%	14
Temperature when Distillate equals the % loss on evaporation at 105° C	....	....	....	298° C.	291

NOTE. All penetrations given are with No. 2 Standard Needle, 100 gram load.
Key to names of materials: 1, 2, 3, Asphaltic compounds; 4, 4A, 7, Refined water-g

09 ON PARK HEIGHTS AVENUE, BALTIMORE COUNTY, MARYLAND

e of Material						
A)	5 (2)	6 (1)	7 (3)	8 (1)	9 (1)	Remarks
ne	None	None	None	None	None	
%	28.17%	24.19%	1.20%	0.19%	28.59%	
.....	....	....	....	0.23%	....	
ıce	0.16%	0.08%	0.05% (1) Trace (2)	Trace	Trace	Analyses are carried out in form and according to method prescribed by the Special Committee of the American Society of Civil Engineers appointed by the Board of Direction to investigate and report on Bituminous Materials, used in Road Construction.
ı%	9.33%	8.43%	13.27%	12.79%	6.39%	
ı8	1.25	1.224	1.316	0.963	1.235	
·c.	264 Sec.	169 Sec.	20 Sec.	2595 Sec.	162 Sec.	
.....	....	....	....	....	....	
·c.	531 Sec.	709 Sec.	Too fluid	917 Sec.	373 Sec.	
%	12.6%	12.75%	36.2%	None	9.75%	
(3) ard	Too hard	Too hard	Too hard	32	3	
	20	13	25 (2) Too hard (1)	161	28	In addition, are also reported, for purposes of comparison with other records, the Losses on Evaporation at 105° for both 3 and 5 hours periods, and Penetrations and Melting points of the Residues; the losses at the end of 3 hours under Evaporation at both 170° and 205°; the Initial Temperatures of the Distillates; and the Temperature when the amount of Distillate equals the Loss on Evaporation at 105° for 5 hours.
	55° C.	60° C.	53° C.	42° C.	48° C.	
%	17.48%	13.90%	36.3%	0.9%	9.90%	
%	21.6%	17.10%	40.7%	1.35%	13.75%	
ard	Too hard	Too hard	Too hard (2) 30 (1)	25	Too hard	
ard	15 (1) Too hard (1)	Too hard	Too hard (2) 120 (1)	125	19.0	
	67° C.	73° C.	67.8° C.	50° C.	50° C.	
%	9.57%	18%	33%	1.85%	14.25%	
	26.27%	22.10%	38.5%	2.90%	19.25%	
ard	Too hard	Too hard	Too hard (2) 12 (1)	21	Too hard	
ard	Too hard (1) 8 (1)	Too hard	Too hard (2) 65 (1)	76	2	
	79° C.	76° C.	79° C.	66° C.	71° C.	
.....	....	....	....	....	....	
.....	38.8%	....	38.8%	1.49%	....	
.....	....	....	Slightly Sticky	80.80% Sticky		
	163° C.	186° C.	129° C.	223° C.	130° C.	
(3) (1)	5% water (1) None (1)	None	None	None	None	
e	0.5% (1) None (1)	None	None (1) 3.05% (2)	None	0.4%	
(2) (2)	1.5%	1.4%	13.9%	0.1%	1.3 %	
	8.4% 14.1%	5.7% 17.3%	24.6% 29.4%	2% 10.2%	12.1% 19.7%	
	280° C.	290° C.	288° C.	296° C.	260° C.	

figures in parentheses ( ) indicate number of samples used to obtain average.
rs; 5, 6, 9, Refined coal tars; 8, Heavy binding oil.

In the latter case, it is also desirable to know whether or not the road material itself is to be heated.

4. Quantity and character of traffic.
5. Climatic conditions.

Because of the very great differences between oils and tars, somewhat different methods of examination are followed. A summary of the most important tests for each are given below:

OIL AND OIL PRODUCTS, INCLUDING FLUXED ASPHALTS.

1. Specific gravity.
2. Flash point.
3. Melting point of solids.
4. Penetration of semisolids and solids.
5. Volatilization at 163 degrees Centigrade for five hours.
6. Solubility in carbon bisulphide.
   (a) Total bitumen.
   (b) Organic matter insoluble.
   (c) Inorganic matter.
7. Bitumen insoluble in 86 degree Beaumé paraffin naphtha.
8. Fixed carbon.

TAR AND OTHER PRODUCTS.

1. Specific Gravity.
2. Melting point of solids.
3. Free carbon.
4. Results of distillation.
   (a) Water.
   (b) Light oils to 110 degrees Centigrade.

(c) Second light oils 110 degrees to 170 degrees Centigrade.

(d) Heavy oils 170 degrees to 270 degrees Centigrade.

(e) Pitch.

The values of the various tests will be briefly discussed.

Specific gravity:—Oil with a specific gravity over 0.93 must be heated. No oil with a specific gravity under 0.95 should be used as a permanent binder. The specific gravity of tar is largely dependent upon the percentage of free carbon. As a rule tars with specific gravity higher than 1.18 cannot be distilled to produce satisfactory road binders unless a lighter tar is mixed with them. Tar with a specific gravity over 1.15 must be heated before using, while tars under 1.15 can be considered merely as dust layers and temporary binders.

Flash point:—The flash point is of little value except as a quick means of differentiating between heavy crude oils and cut-back products or fluid residues. Crude oils usually have a lower flash point than residual oils and paraffin oils usually flash at a lower point than asphaltic oils.

Melting point:—The determination of the melting point is mainly of value as a means of identification and for control work on the part of manufacturers, although it influences the selection of material to conform with climate to some extent, especially in the case of tar products. If the penetration method is to be employed, a tar product should have a melting point not over 25 degrees Centigrade and a blown oil not over 30 degrees.

Penetration:—The determination of penetration is of importance, as is the determination of the melting point,

for work of identification and control. The test also influences to a certain extent the selection of materials. For example, no oil product should be used for macadam construction if its penetration is higher than 25 millimeters at 25 degrees Centigrade with a number 2 needle, unless it possesses the property of hardening when subjected to the volatilization test.

Volatilization:—This test is purely arbitrary, but it is of considerable value when applied to road oils. It consists in determining the loss in weight of 20 grams of oil when subjected to a uniform temperature of 163 degrees Centigrade for five hours in a standard size dish. If a material is desired to maintain a certain consistency after application, it should not show much loss by volatilization; but if a material must be soft at time of application because of the method employed, it should show considerable loss in order that it may eventually be capable of attaining proper consistency. The determination of penetration of the residue is important as showing the nature of the material after setting up.

Solubility in carbon bisulphide:—The test is especially important for tars because of its determination of the percentage of free carbon. A knowledge of the free carbon content is very important both for determination of the class of the tar as regards manufacture and also as an indication of its adaptability for various forms of construction. The effect of free carbon in tars from the standpoint of road treatment has been investigated by the author. The results of this investigation demonstrate the following facts:

1. That in tars of the same consistency those of low carbon content have a greater inherent binding strength than those of high carbon contents.

2. That in tars whose bitumen contents are of the same consistency, those of high carbon contents have a greater inherent binding strength than those of low carbon contents, but that the binding capacity of the former is lower.

3. That in sand-tar mixtures containing a relatively large amount of high carbon tar, the carbon may act as a filler, and add to the mechanical strength of the mineral aggregate, but that better results in this respect can be obtained by the use of a smaller quantity of low carbon tar of the same melting point, together with a mineral filler.

4. That the waterproofing value of high carbon tars is in general less than that of low carbon tars.

5. That free carbon retards the absorption of tars by porous surfaces.

6. That when tar is exposed in comparatively thin films free carbon has little or no effect in retarding volatilization.

In view of the foregoing a low carbon tar is preferable to a high carbon tar for surface treatment of old roads, and also in construction work, provided the consistency is the same.

Bitumen insoluble in 86 degree Beaumé paraffin naphtha:—This test is important for oils as indicating the amount of body-forming hydrocarbons which give mechanical stability to the materials. No oils having less than 4 per cent insoluble will be valuable except as dust preventives. The character of insoluble matter should be noted as to whether or not it is sticky. A sticky residue indicates better road binding qualities.

Fixed carbon:—This test is an indication of the mechanical stability of an oil. Fixed carbon is the coke resulting

from the ignition of the material away from the air, and should not be confused with free carbon. It is not a very accurate test, and hence too great reliance should not be placed on it.

Distillation:—As applied to tars it is very valuable both as an indication of their road binding properties, and the method of preparation if they are refined tars. All crude tars contain water, and the amount of this may be judged from the tests. The test often determines whether or not the product is a mixture of tar and oil. Refined tars should not show over 7 to 8 per cent by volume of distillate up to 170 degrees Centigrade, and the total distillate should show when cold but little precipitated naphthalene, since this substance is not desirable because it gives a false consistency and volatilizes quite readily.

CHAPTER VII

FOUNDATION AND DRAINAGE

Böltz, Johann, *Imperial Chief Commissioner of Public Works*, Laibach, Austria.

Lelièvre, Charles, *Honorary District Inspector*, Versailles, France.

Pierce, Vernon M., *Chief Engineer, U. S. Office of Public Roads*, Washington, D. C., U. S. A.

Pierret, Léopold, *Chief Engineer of Bridges and Roads*, Amiens, France.

Skougaard, J., *Director-General of Bridges and Roads*, Christiania, Norway.

Vandone, Italo, *Chief Engineer of the Province of Milan*, Italy.

Van Volsom, Edgard, *Engineer of Bridges and Roads*, Brussels, Belgium.

Austria. Johann Böltz. The ordinary foundation used in Austria is of the Telford type. Water is carried in side ditches, and the old custom of carrying the water across the road, where necessary, in surface drains is giving way of late in favor of culverts.

Belgium. Edgard Van Volsom. Stone foundations are the most commonly used for macadam roads. Stones are placed by hand as close together as possible and wedged with spawls. The stones may be laid on the bottom of

the road trench or, where conditions demand, upon a layer of sand or cinders. After laying, this foundation is rolled with a steam roller to a uniform thickness of 6 inches, 7 inches or 8 inches as desired. This type of foundation may be strengthened by placing stone slabs laid flat between the ground and the usual form of foundation. Concrete and reinforced concrete have not as yet been much used for foundations for macadam roads.

Paving is almost always laid on a layer of sand from 4 inches to 8 inches thick, spread at the bottom of the road trench, unless the nature of the ground requires the introduction of a bed of cinders between the ground and the sand foundation. As a rule no foundations, properly so-called, are provided. Nevertheless, in order to avoid the sudden deformations which occur in paving laid on a sand foundation only, unless the ground is particularly firm, some trials of paving on foundations have been made in Belgium. The City of Antwerp has used foundations of broken stone about 10 inches thick and covered with 2 inches of sand. This form has proved satisfactory. In Brussels broken stone and refuse destructor slag have been used together for foundations. The slag contains lime and consequently acts as a binder for the stone. Satisfactory results have been obtained by this method. Granulated slag concrete has been used to some extent placed 6 inches thick and covered with about 2 inches of sand. In one instance the cost of this foundation was 18 cents per square yard. The proportion of materials used for this concrete was 10 parts slag to 1 part of cement. In Brussels a foundation 6 inches thick of broken brick mixed with a mortar of 15 parts sand and 2½ parts of hydraulic lime was used. Concrete slabs were used at Vilvorde. The slabs were

made of 7 parts by volume of granulated slag from blast furnaces, which had been ground and mixed with 1 part of cement. Two sizes of slabs were used: 16 inches by 17 inches by 6 inches and 16 inches by 16 inches by 4 inches. A sand cushion 4 inches in depth was placed between the blocks and the slabs. Good results were not obtained because the blocks were tapered too much and the sand layer was too thick.

France. CHARLES LELIÈVRE. Sand foundations are valuable under both pavements and macadam roads. The incompressibility of such a foundation, as well as its cushion effect to prevent abrasion of the two adjacent courses, recommends it for use under pavements. The use of sand under macadam roads is a later development, but is found very beneficial where the ground is loose but not waterlogged and for the general prevention of the substratum oozing through the stone layers. Sand foundations should be wet and well rammed.

Brick and plaster rubbish compressed to a thickness of from 4 inches to 8 inches is often very efficacious.

Simple lime concrete and ordinary cement concrete of various proportions is laid 4½ inches to 8 inches thick for a foundation.

Reinforced concrete is used in order to give more rigidity to the foundation. The transversal reinforcement bars tie the longitudinal ones together, their number varying according to the intensity of traffic.

Paving on an old macadam surface is practical and advantageous. The old road must, however, be reprofiled, drained and covered with a thin bed of sand.

Given an equal thickness, it is possible to classify in order of increasing resistance the different kinds of foundations as follows:

1. Quarried stone or pieces of stone of all sizes simply spread on the bed.
2. Stone or flags placed flat to form a distributing footing.
3. Pointed stone with the joints wedged by hand and with small stone and sand filling.
4. Rough-hewn stone on edge bonded in form of an arch.
5. A homogeneous mass of coarse shingle, 3 inches to 4 inches in size, well compressed.
6. A mass of coarse shingle or gravel, 1¼ inches to 2½ inches, well rolled.
7. A mass of clean sand, compacted and compressed.
8. The same mass watered with milk of lime.
9. Masonry.
10. Concrete with hydraulic mortar.
11. Concrete in cement mortar.
12. Reinforced concrete.

The information which has been supplied from the different Departments of Roads of France shows that the most widely used form of foundation on roads located outside the towns and villages, particularly on the old main roads, is stone blocks varying from 6 inches to 8 inches or even 10 inches thick, placed in position by hand, system Tresaguet, or a bed of coarse shingle or flags of sandstone from 3¼ inches to 4 inches by 6 inches to 8 inches thick. In modern roads there has been employed a layer of packed stone of 6 inches to 8 inches thick resting directly on the substratum or on a bed of gravel, sand or plaster and brick rubbish. Also, a simple bed of sand 6 inches to 10 inches thick under the stone metalling has been used in certain

cases and occasionally a bed of concrete 5 inches to 6 inches thick.

It is of the utmost importance to secure thorough drainage. To secure surface drainage removal of mud is a necessity. After the road is cleaned and is soft from being impregnated with moisture, as is the case after a thaw, the use of a heavy roller is advantageous. Protective coatings of bituminous substances on the surfaces of roadways as a rule aid surface drainage. Roadsides should be sloped well and should preferably be compacted with sand or rough stone.

Raised shoulders at one time existed along the greater portion of the main roads; but recently, unless the grades are steep and paved gutters and curbs are employed, the simple roadside is preferred. The value of the raised shoulder on steep grades lies in the prevention of the cutting of the roadside by vehicles, which in descending use the shoulder as a brake because of its greater resistance to traction. The chief disadvantages of the raised shoulder are: first, that in level regions the flow of surface water from the road is hindered and, second, that the cross gutters which are necessitated for allowing the water to run off are disagreeable for foot passengers unless they are bridged over at considerable expense.

Side ditches aid in the drainage of a road and prevent infraction of rights of adjacent landowners. Riparian owners should be compelled to build crossovers over ditches at their own expense. Percolation pits are sometimes used for securing underground drainage. This form of drainage consists simply in digging through an impervious layer to a pervious layer and filling the hole with rough stone. It is applicable only in cases where the impervious layer is thin.

The depth at which drains should be laid beneath the road surfaces should not be lower than 2 feet, 3 inches, to 2 feet, 6 inches, and the spacing of the lines of drain may vary from 16 feet to 50 feet. There should always be, however, a relation between the depth and the spacing according to the retentive power of the ground for water. The gradients of the drains should not be less than 0.002 for pipes, and 0.005 for stone conduits. The maximum slope should not exceed 0.03 or 0.035 per thousand. The most common form of underground drain is loose stone or flagging shaped in the form of a conduit. Earthenware pipes are seldom used because of liability of breaking.

France. Léopold Pierret. Metalled roads should be laid on foundations on all ground other than frost proof rock. Rock which is not frost proof should be excavated below the frost line and the excavation filled with good earth or sand. In sandy clay, sand or clay excavations, the foundation may consist of a layer of a poorer and a larger grade of stone than is used in the wearing surface. The thickness of the foundation varies between 4 inches and 9 inches, depending upon the quality of the metal selected, the nature of the soil, the amount and nature of the traffic. In constructing metalled roads in marshy or soft lands special methods have to be adopted, such as layers of fascines or of brushwood. Drainage should be provided in all cases.

Paved roads must always be laid on foundations of sand varying in thickness from 2 inches to 10 inches. The foundation is placed directly on the surface of the ground if it is frost proof or if well drained. In cases where the ground cannot be well drained, the earth should be taken out to a depth of 8 inches to 9 inches and replaced with sand. The sand used must be clean and of medium size. It

should be spread in layers 3 inches to 4 inches in thickness which should be carefully watered and rammed.

In towns the importance of the traffic may justify the construction of a concrete foundation from $4\frac{1}{2}$ inches to 8 inches in thickness. A layer of sand 2 inches to 4 inches thick should be placed between the pavement and the foundation to act as a cushion.

Italy. Italo Vandone. In the construction of a road from Binasco to Rosate in the Province of Milan, the subsoil encountered was a fine gravel covered with a thin coat of mould. The section built had a concrete foundation under the centre of the road, the theory being that the travel would largely be concentrated at the centre. This foundation had a width of approximately 9 feet, and depths of $5\frac{1}{2}$ inches at the centre and $4\frac{3}{4}$ inches at the sides. The crown of the road was given an elliptical form.

Norway. J. Skougaard. Particular care is taken in the building of State Roads in Norway that a very thorough drainage of the subsoil is secured.

Underground drainage is usually secured by ditches at each side of the road, or frequently, where the ground slope is at right angles to the direction of the road, one ditch on the upper side is sufficient. These ditches are dug to a depth of from 18 inches to 24 inches with side slopes of 1 to 1.5, the width at the top varying from 3 feet to 5 feet. In marshy ground the ditches are dug to a depth of about 3 feet and a space from 3 feet to 5 feet is left between the road and the edge of the ditch. When the road is cut into rock, the ditches are cut about 18 inches deep with a bottom width of 14 inches to 18 inches.

It is customary to construct at intervals, not usually exceeding 325 feet, small bridged conduits across the road.

These conduits are used in large embankments where the roads encounter an infiltration of water, and are built with good gradients towards the ditches. They are usually constructed as covered drains of dry stone masonry with a cross-section of about 2 feet by 2 feet, but the dimensions vary under different conditions. Reinforced concrete pipes are often employed in place of dry masonry construction. In ground consisting of unstable sandy clay a system of drainage consisting of closed drains laid in the roadbed is frequently employed. These drains are filled with stones. In clay or marshy ground a bed of sand is frequently laid below the foundations.

United States. Vernon M. Pierce. The improved roads of the United States may be divided into four classes, according to the method in which the foundation is formed: (1) those having no artificial foundation, but in which the covering materials are placed directly on the natural soil, the surface of the ground being shaped only; (2) roads having a paved foundation; (3) roads having a foundation of concrete; (4) those having miscellaneous foundations of material such as gravel, broken field stone, cinders, brickbats, etc. Of the approximately 200,000 miles of improved road in the United States, by far the largest mileage comes under the first class. This is perfectly natural. The demand is constantly for a road at the lowest possible cost. This has led not only to a considerable reduction in the thickness of our macadam roads, but also to a utilization of the natural soil as a foundation wherever possible. Many failures have resulted, but the failures have not been without their value, for from these failures as well as the successes certain fundamental facts and principles have been impressed so strongly on the road

builders that fewer mistakes and failures are likely to result in the future.

The United States presents a great variety of conditions in climate, topography, soils, and character of traffic. Naturally, the construction will have to be modified to meet the various requirements, and this fact must be borne in mind, for while the most general practice is here set down, there are frequent and marked deviations arising from our varied local conditions.

Earth foundations should be carefully drained, thoroughly compacted, crowned the same as the finished road, and should be freed from all vegetable matter. Where the road is built on an embankment, the earth fill should be laid in layers not exceeding 6 inches in depth and each layer thoroughly compacted with a roller. If necessary, water should be added so that the material will puddle well.

Paved foundations are usually known as telford foundations in the United States. They are much less frequently used than earth foundations. The common method employed is to use stones about 6 inches to 8 inches high, 3 inches to 8 inches wide, and 6 inches to 15 inches long placed with their longest dimensions at right angles to the axis of the road. Spawls are used to wedge the stones. The foundation is rolled with a power roller, and stones which show a tendency to shift position materially should be removed. This method is expensive in the United States because of the high cost of hand labor and teams.

Concrete foundations are probably the best road foundations in use at the present time. Concrete is strong and practically homogeneous and therefore able to distribute the stresses from traffic over a considerable area, and is in addition fairly impervious, so that it assists in

protecting the soil subgrade from surface moisture. Both Portland and natural cements are used, but the use of Portland is much the greater. Concrete is used very largely for the foundations of city pavements, and is being used somewhat in country districts as a foundation for brick or bituminous macadam surfaces. The general tendency is to lessen the thickness of concrete foundations, the former practice being to build them 8 inches in depth, while 6 inch and even 4 inch concrete foundations are now common. The concrete should be laid in strips across the full width of the road as soon as possible after mixing and then tamped or rolled with a light roller.

Among the miscellaneous foundations used are those built of broken stone, brickbats, gravel, materials scarified from old pavements or roads, logs, planks, and slag. The first four forms are built from 4 inches to 12 inches in thickness and should, as a rule, be filled with sand. Logs are sometimes used in land where the level of the ground water is practically always at the surface of the ground. Such construction is called a corduroy road. Plank foundations are cheaper and more satisfactory, and hence are more frequently used. Slag from iron and steel furnaces and ore smelters has been successfully used. Acid slag forms only a physical bond, while basic slags form a chemical bond which binds all the particles together thus forming a homogeneous foundation. It seems probable that slag foundations will be a success and prove economical in some localities after further experimental work.

The most important principle involved in road building is that of thorough and proper drainage. The soil upon which the road bed is placed must eventually bear the loads passing over the road. The intensity of the

pressure is of course not nearly so great on the soil as on the wearing surface of the road, since the severe wheel pressure becomes distributed over a much larger area, the amount of distribution depending on the thickness, character and condition of the roadway materials. But, whatever the distribution, the load is finally transmitted to the soil. Most soils can be so compacted as to form a good firm foundation as long as they are kept dry.

Surface drainage is accomplished by using more or less impervious materials for the surface coat and by having the crown of the road sufficient to throw the water off.

Ditches and cross drains should be designed to take the largest storm flow. The grade of the bottom of a ditch should not be less than 6 inches in 100 feet. As a rule gutters or side ditches in the country are unpaved except on steep grades.

Cross drains or culverts are made of wood, earthenware, iron, cement and concrete, both reinforced and plain. Iron and reinforced concrete seem to be the materials best adapted to a cold climate because of the liability of other forms to crack by clogging and subsequent freezing. All culverts should have their ends protected by concrete headwalls.

Tile pipe is generally used for removal of ground water. A line of tile pipe may be placed on both sides, on one side only, or under the center only, according to the conditions met with. Where the flow of ground water is mostly in one direction, one line of tile pipe on the side to keep it away from the road is sufficient. In heavy soils two lines of pipe will often be found necessary. In these soils it is well to lay the tile pipe on a layer of sand about 4 inches

deep and cover it with sand to a depth of at least 1 foot. This plan prevents the pores of the pipe from becoming clogged.

One of the later methods employed to drain the subsoil which has given satisfaction, is the construction of the "V" drain. In this work the subgrade should be excavated for the full width of the surfaced roadway, from 6 inches to 8 inches deeper at the sides, and from 12 inches to 18 inches deeper at the center than usual, thus producing a flattened "V" shaped trench. This extra excavation is filled with pebbles and boulders varying in size from ½ inch to 12 inches in their longest dimensions. The largest stones are placed in the bottom of the trench, which should be graded longitudinally so that the water will run easily.

Details of the practice of sub-drainage vary largely in the different sections but the employment of longitudinally tiled and "V" shaped drains to collect and carry off the water is very extensive and is rapidly increasing. Road builders are learning more and more from experience that as a rule it is cheaper in the end and more satisfactory to drain the roads than to lay expensive foundations. To keep the earth dry, hard, and unyielding is necessary to secure low cost of maintenance and long life of a road. Therefore, the water falling on the road must be carried off quickly and effectively and the water from below must be intercepted and removed before it reaches the road bed where it can do damage.

CHAPTER VIII

MACADAM AND GRAVEL ROADS

De Jaegere, Alberic, *Civil Engineer*, Antwerp, Belgium.

Fletcher, Austin B., M. Am. Soc. C. E., *Secretary, Massachusetts Highway Commission*, Boston, Mass., U. S. A.

Glasner, Antoine, *Engineer*, Budapest, Hungary.

Karakoulakoff, Paul, *Engineer, Ministry of Public Works*, Sofia, Bulgaria.

Le Gavrian, P., *Engineer of Bridges and Roads*, Versailles, France.

Mikhaïloff, Paul, *Engineer of Highways*, St. Petersburg, Russia.

Rablin, John R., M. Am. Soc. C. E., *Chief Engineer, Metropolitan Park Commission*, Boston, Mass., U. S. A.

Skougaard, J., *Director-General of Bridges and Roads*, Christiania, Norway.

Belgium. Alberic De Jaegere. The first class macadam roads of Belgium consist of a layer of rough-hewn stone and spalls 7 inches in thickness covered by two layers of broken stone which together make a thickness of 5 inches after compacting.

The bed of the foundation, previously dressed parallel to the finished surface, is rolled by means of horse drawn rollers weighing 6 tons with their ballast load. The rough stones are set so that their greatest dimensions are at right angles to the road axis and are wedged together by a maul

in such a manner that after this operation it is not possible to remove a single piece without using considerable force. This course is compacted to the prescribed thickness of 7 inches. On this stone bedding, previously cleared of all débris, is spread the first bed of metalling, which is compacted until no further impression can be made on it. The roadway is afterwards covered with the second layer of metal to the required thickness, which, after rolling, forms the desired profile. The rolling of the second layer of metal is continued in such a manner as to compact the whole mass thoroughly and to form a uniform surface, the metalling of which does not spring under the roller. The requisite quantity of fine material is spread gradually and as uniformly as possible during the continued rolling, and is forced into the metalling by means of wire brooms. The rolling is performed by means of a steam roller weighing at least 14 tons, and is accompanied by watering, using 7 gallons per square yard of surface. Constructed under such conditions, the macadam costs about 81 cents per square yard. The repairing of this surface is done by means of remetalling; namely, by spreading a new bed of fine metal and rolling with a steam roller. The life of macadam, with the exception of the remetalling, is nearly infinite, because the hewn stone which forms the foundation is never subjected to wear. The cost of maintenance per square yard per annum is on an average from 6.5 cents to 8 cents. This is, therefore, a very economical road surface, but it is not suitable for streets which have heavy traffic. In towns, macadam is now only used for park roads and on certain parts of boulevards.

Bulgaria. Paul Karakoulakoff. In the construction of macadam roads in Bulgaria the surface stratum is

laid on a bottom course of quarry stone 6 inches to 8 inches in thickness, the stones being of a truncated pyramid section. This bottom course is always laid on a foundation well levelled and rolled. On firm ground it is, from motives of economy, made of rubble instead of quarry stones. On the bottom course a layer of metalling or gravel about 6 inches to 8 inches in thickness is laid. The size of broken stone varies from 1½ inches to 2⅓ inches according to the quality of the stone. When the metal surfacing has no foundation below it, its thickness varies between 8 inches and 14 inches according to the degree of firmness of the ground. Finally, after the metal surfacing has been thoroughly compacted, a layer of sand or stone chips from ¾ of an inch to 1½ inches in thickness is spread over it and rolled.

France. P. Le Gavrian. Among the limestone binders which may be used in macadam road construction are included calcareous sand, marl, chalk and soft limestones, dolomite, etc., all of them being substances which, if mixed with stone of a hard nature, such as flint, quartz, etc., form a magma of material easily consolidated but without any real setting. These materials make up for the want of cohesion of hard, smooth substances, which compression alone could never solidly bind together. A number of these materials have been used for a long time past in a great many parts of France where, indeed, they are still regularly and ordinarily employed for road metalling. These perceptible inert binding mixtures, while being good enough for highways bearing a moderate amount of traffic, are quite insufficient on roads with much traffic on them, especially if it consists of highspeed automobiles.

Hungary. Antoine Glasner. In the construction of the usual type of metalled roads a layer of metal 4 inches

to $4\frac{1}{3}$ inches deep is rolled with a steam roller until the pieces of stone are levelled to the desired profile and form a layer firm enough to preserve its cohesion under a light vehicle. The rolling is accomplished by means of a steam roller weighing from 13 to 15 tons, water being sprinkled on the surface as the rolling progresses. Then a layer of chips ¾ of an inch deep is laid over the surface and rolled. The chips are forced into the interstices of the surface by the pressure of the roller, thus forming a firm mosaic like structure. Even in this condition, however, the road is not opened to traffic until a covering of sand from ½ of an inch to ¾ of an inch deep is spread over it.

Norway. J. Skougaard. The great majority of our roads are constructed with a broken stone surface resting on a layer of rough-hewn stone. It is a method of construction which, with some slight modifications, has been maintained by us since the introduction of modern systems of road design in Norway.

For some years past rolling has been more and more common, a horse drawn roller being employed. The use of binding material is always necessary, clayey gravels being preferably used or, if such material is not procurable, clay itself. The fine binding materials are usually spread on the road, after the stone surface is thoroughly rolled, in such quantity as to fill the interstices and slightly cover the metal itself. Then follows a careful rolling, after which the roadway is again covered with a thin layer of clean gravel.

Russia. Paul Mikhaïloff. In Russia the macadam type of road is usually adopted, the thickness of metalling varying from 6 inches to 10 inches laid on a foundation of sand and gravel. When clay, marl or peaty soil is encountered, it is customary to excavate and spread a 6 inch

layer of sand to secure drainage and the stability of the thin stone metalling. By such a method, the water is kept from penetrating the stone layer and good results have ensued.

United States. Austin B. Fletcher. The method of construction of macadam roads in Massachusetts is as follows: After properly shaping and rolling the subgrade, broken stone is laid so that the depth after rolling will be 6 inches at the center and 4 inches at the sides. This depth is varied according to traffic and subsoil conditions. The bottom course consists of stones varying from 1¼ inches to 2½ inches in their longest dimensions, and the upper course of stones varying from ½ inch to 1¼ inches in their longest dimensions, the depth of the courses being usually 4 inches for the lower and 2 inches for the upper. Each course is rolled with a roller weighing from 10 to 15 tons. After both courses are thoroughly compacted, broken stone screenings, containing the fine dust, are spread, watered and rolled until the interstices of the stone are substantially filled.

A 15 foot road of this type will require about 1 ton of trap rock per 3.13 square yards. These roads have given excellent results until the advent of the motor car.

United States. John R. Rablin. In the early development of the Metropolitan Park System of Boston it was found that macadam roadways built with a soft grade of stone were much more easily maintained than those constructed with trap rock. The class of traffic on these roads does not wear trap or other hard rock enough to supply the binder necessary to keep the roads in good condition. The stripping of the surface of ordinary macadam roads by the motor vehicle traffic has made it necessary to adopt other methods of construction.

CHAPTER IX

DUST PREVENTION BY THE USE OF PALLIATIVES

Balló, Alfred, *Commissioner of Street Cleaning*, Budapest, Hungary.

Franze, Gustav, *Commissioner of Public Works*, Frankfort-on-the-Main, Germany.

Froidure, Eugène, *Principal Engineer of Bridges and Roads*, Ypres, Belgium.

Karakoulakoff, Paul, *Engineer, Ministry of Public Works*, Sofia, Bulgaria.

Le Gavrian, P., *Engineer of Bridges and Roads*, Versailles, France.

Rablin, John R., M. Am. Soc. C. E., *Chief Engineer, Metropolitan Park Commission*, Boston, Massachusetts, U. S. A.

Skougaard, J., *Director General of Bridges and Roads*, Christiania, Norway.

Sperber, *Chief Engineer*, Hamburg, Germany.

Verstraete, Richard, *Engineer of Bridges and Roads*, Bruges, Belgium.

Belgium. Eugène Froidure and Richard Verstraete. The use of calcium chloride will not supplant surface tarring in Belgium. The process is temporary in effect and is rendered useless if a rain occurs soon after application.

Bulgaria. Paul Karakoulakoff. In the combat-

ing of dust, Bulgaria has not as yet achieved anything of consequence. No coal tar is produced in the Kingdom, and wood tar is produced only in inconsiderable quantities. Hence, the tarring system is too costly to install. The efforts of road engineers are largely directed toward improvement of present conditions by the use of materials which will not crumble easily.

France. P. Le Gavrian. The use of oils as palliatives is very limited in France. There are, however, many emulsions in use, a typical one being Westrumite. The trials in France in many departments confirm the opinion already recorded at the First International Road Congress that they are only efficient for a short time and that the spraying has to be repeated several times in the season. The cost per square yard soon becomes prohibitive. They are, therefore, "processes *de luxe*," the utility of which is only apparent when it is a question of sprinkling as quickly as possible a certain length of road for a race or a procession. Ordinary watering is very temporary in its action. The methods of applying have been greatly improved. Motor cars fitted with fine sprays prevent an excess of water being applied and do the work very rapidly. Chloride of sodium dissolved in water has lasted in some cases three or four days, but it is considered to be insufficiently hydroscopic. Chloride of magnesium and calcium chloride have a much greater affinity for water than has sodium chloride and are consequently more effective. The proportions used have varied greatly, so the results are very variable. Dust has, however, been very successfully laid in many localities by using these salts. The writer considers that, although the use of these salts could never become general, they may be useful in many cases.

Germany. Sperber and Gustav Franze. Water sprinkling is inefficient for general use because of its imperfect action and its very short life. For country roads the usual necessary long distances between filling points makes water sprinkling costly and unsatisfactory.

Calcium chloride, chloride of magnesia, and sea-salt solutions, because of their short period of efficiency, are usually applicable only to asphalt, wood or stone block pavements. Applications of these salts must be made at intervals of from two to fourteen days depending upon the weather and amount of traffic. These materials can be applied with profit only in the municipal watering areas. Often solutions of these salts, because they do not freeze readily, are very good for sprinkling the roads before sweeping in cold weather.

Owing to the small percentage of oils sprinkled on the road, when emulsions are employed, the process must be repeated frequently. In the writer's opinion even rich municipalities cannot use this process on extensive areas of macadam because of the high cost of frequent applications and consequently must limit its use to asphalt and wooden pavements.

Hungary. Alfred Balló. As hygroscopic salts failed to give good results, the Office of Public Cleanliness made numerous experiments with oils. Unrefined petroleum was considered too inflammable and odorous. A petroleum by-product, called "blue oil," which gave still better results after being refined, was finally selected.

The usual number of applications is three, one in early spring, the second four to six weeks later and the final application six to ten weeks after the second. The road is first swept and the material applied, unheated, from ordinary water-carts. The first application is usually 2 pounds and

the other two one-half that amount. The cost is found to be only slightly in excess of that for watering.

Norway. J. Skougaard. The maintenance of roads has not developed parallel with the construction of roads. Sprinkling tar and oil on the road surfaces is altogether too costly at present for general use and the need for such treatment has not been keenly felt where cleaning has been properly done.

United States. John R. Rablin. The use of calcium chloride for laying the dust has proved satisfactory on a number of shaded roads which are used exclusively by light horse drawn vehicles. One application about every four weeks was required. On roads where there is considerable motor vehicle traffic, the use of calcium chloride did not prevent the automobiles from disintegrating the surface and in a short time the roads would require resurfacing

CHAPTER X

BITUMINOUS SURFACES

Bradaczek, Theodor, *Imperial Commissioner of Public Works*, Prague, Austria.

Corazza, Cesare, *Engineer*, Turin, Italy.

Crosby, Walter W., M. Am. Soc. C. E., *Chief Engineer to the Maryland Geological and Economic Survey*, Baltimore, Maryland, U. S. A.

Drummond, Robert, *County Surveyor, Renfrewshire*, Paisley, Scotland, Great Britain.

Étier, Paul, *Councilor of State*, Lausanne, Switzerland.

Fletcher, Austin B., M. Am. Soc. C. E., *Secretary, Massachusetts Highway Commission*, Boston, Massachusetts, U. S. A.

Franze, Gustav, *Commissioner of Public Works*, Frankfort-on-the-Main, Germany.

Froidure, Eugène, *Principal Engineer of Bridges and Roads*, Ypres, Belgium.

Hooker, S. Percy, *Chairman, New York Highway Commission*, Albany, New York, U. S. A.

Le Gavrian, P., *Engineer of Bridges and Roads*, Versailles, France.

Rablin, John R., M. Am. Soc. C. E., *Chief Engineer, Metropolitan Park Commission*, Boston, Massachusetts, U. S. A.

Ross, Charles W., *Street Commissioner*, Newton, Massachusetts, U. S. A.

Schlaepfer, Arthur, *Street Inspector*, Zurich, Switzerland.

Sperber, *Chief Engineer*, Hamburg, Germany.

Tedeschi, Massimo, *Engineer*, Turin, Italy.

Verstraete, Richard, *Engineer of Bridges and Roads*, Bruges, Belgium.

Wenner, Victor, *City Engineer*, Zurich, Switzerland.

Wynne-Roberts, R. O., M. Inst. C. E., F. R. San. Inst., Westminster, London, England, Great Britain.

Austria. Theodor Bradaczek. Based on the fundamental principle that the tar macadam system of road construction is almost as expensive but is not as durable as that with basalt or granite kleinpflaster, we in Bohemia have concerned ourselves only with surface tarring, and have confined it to stretches which are subject to traffic of light vehicles and automobiles, such as those of the roads connecting the two watering-places, Karlsbad and Marienbad.

Belgium. Eugène Froidure and Richard Verstraete. Crude tar direct from the gas houses is employed for surface tarring. This tar was obtained at a cost of $4.82 per ton in 1909. The results attained vary considerably, although as a rule the dust is satisfactorily laid.

Surface tarring is done both by machine and by hand. The type of machine usually employed for spreading the tar is a watering-cart fitted with mechanical brushes and hauled behind a steam roller. The roller is fitted with a tank for heating the tar. The tar flows from the heating tank to the watering-cart, from which it is sprinkled on the

road. The road is previously swept by horse sweepers. The average amount of tar used by the machine method is 0.23 of a gallon per square yard, the total cost being about 0.73 cents.

Where hand work is employed the amount of tar used is 0.19 of a gallon per square yard and the total cost is about 0.66 cents. It is cheaper than the machine method principally because the deterioration of machinery is a fairly large item. The hand method has several advantages to recommend it besides low cost. There is no apparatus to get out of order, ordinary workmen may be employed, and the method offers less inconvenience to traffic because the top dressing may be kept close up to the edge of the tarred area. The chief advantage of the machine method is speed.

France. P. Le Gavrian. Superficial tarring has increased noticeably in France of late years. Spreading or spraying the tar is accomplished by means of hand sprinklers or by machines consisting of tanks on wheels with brushes attached. The tar is generally heated to 100 degrees Centigrade, but in a number of localities cold tar is rendered fluid by adding 10 per cent of heavy oil. The average amount of tar used for the first application is about ¼ of a gallon per square yard and subsequent applications are made with less quantity.

The method of burning the tar, after it has been spread on the roads, has been tried in several places but has not been generally adopted. Tar in the form of powder has been applied in some cases.

The life of surface tarring is dependent so largely upon climate, quality of materials, and amount of traffic that the writer does not draw conclusions on this point. The majority of engineers consulted were of the opinion that the

process should be done yearly. The writer believes, without committing himself to figures, that in a dry season the life of a road is sensibly lengthened by tarring, and that in a wet season tarring preserves the road as long as the road surface is not destroyed by the combined action of traffic and rain. These conclusions hold, however, only up to a certain amount of traffic, since, when this amount is exceeded, mud is formed just the same as on non-treated roads. Where this limit of traffic is greatly exceeded this tarry mud, stirred up and churned by the wheels of vehicles, never dries and becomes an element of disintegration.

Germany. Sperber and Gustav Franze. As a rule there are no specifications for the tars to be employed, although it is recognized that they should be freed as much as possible from water and ammonia without removing the volatile oils. Liquid oils, creosote oils, and petroleum distillates are sometimes employed to thin the tar. Crude gas tar is the material most frequently used, although refined tar has been employed to a limited extent. The road surface should be warm, somewhat porous, and perfectly dry in order to secure good results. The roads are first well cleaned and the heated tar is then applied by hand or machine. Many towns recommend surface tarring to be applied to macadam roads from six to eight weeks after construction in order to secure the best results. Sand is generally used as a top dressing, although stone dust and roadside dust are employed in some cases. Most towns open the road immediately after treatment; and they prefer machine tarring to hand tarring because of the greater rapidity and uniformity of the work. One horse drawn tarring machine will cover from 3,600 to 7,800 square yards of surface in a day of ten to fourteen working hours.

The majority of towns consider rolling necessary. The average cost per square yard of the hand surface tarring is 4 cents and of machine tarring is 3.2 cents. Subsequent applications may be done at somewhat less expense. Most towns state that tarring is cheaper than watering. The life of the first tarring is stated to be about one year. Under severe traffic the period of wear is reduced to about one-half year. Wet weather and shady location are two conditions mentioned as being injurious to surface tarred roads.

Great Britain. Robert Drummond. With regard to the general tendencies of practice in Scotland, the following statements may be of interest. In populous districts the new macadam surfaces are either bound with tarred chippings or with a tar composition applied by means of a spraying machine.

Ordinary surface tarring has been found effective for one year on roads subjected to heavy traffic and for a longer time on roads with lighter traffic. The cost of superficial tarring, exclusive of the cost of sweeping and sanding, is from 1½ cents to 2 cents per superficial yard. The method of resurfacing with tarred chips is as follows: the road to be repaired is first scarified, new metal is applied and the road is rolled until a hard and smooth surface is obtained; then without the use of water a coating of tarred chippings is applied, rolled and sprinkled with dry chippings during the process of rolling. The addition of dry screenings during the final rolling facilitates the rolling and also gives a finished surface, which at once allows the traffic to pass over the road. The additional cost of binding with tarred basalt or whinstone chippings is 2 cents per superficial yard.

Great Britain. R. O. Wynne-Roberts. Before old road surfaces are tarred all pot holes should be repaired.

The dust should be brushed off, leaving the joints between the stones exposed as much as possible. The road should be dry and warm as damp surfaces chill the tar and reduce the penetration. The tar can be distributed either by hand or by machine, the latter method being much more rapid, but brooming may have to be resorted to with either method to prevent the tar from ponding. Time should be given the tar to soak into the surface until a durable and plastic skin is formed, and during this time traffic should be diverted from the road. Covering the tarred surface immediately with sand or chips does not seem warranted, but if such a covering is used, it should be a light one and evenly spread. It is useless to tar roads built on a wet subsoil that is not efficiently drained. Refined tar is preferable to crude tar because it is free from water and light oils, is more uniform in quality, is more lasting, and if applied hot it will not peel from dry stone surfaces.

Italy. Massimo Tedeschi, and Cesare Corazza. Surface tarring has been used to a considerable extent in Italy. The first trials of this method were carried out in 1901 at Lugo, while in 1902 the Province of Turin commenced surface tarring, which process of laying dust has been continued there until the present time. Surface tarring has been uniformly successful in laying dust and in preserving the road surface. In sections exposed to violent winds, which rendered the maintenance of ordinary macadam a difficult problem, the application of tar has been found to be very effective. The cost of surface tarring in Italy varies from 1.6 cents to 3.2 cents per square yard.

Switzerland. Paul Étier. Tarring is the sole means employed to cope with dust. Surface tarring is considered short-lived on roads where the traffic is excessive, because

it cannot prevent internal dislocation. The first tar spraying is estimated to cost about $300 per mile for a 20 foot road, and subsequent annual renewals cost in the neighborhood of $100 per mile, the lower cost being due in part to the lessened cost of sweeping and cleaning.

Switzerland. VICTOR WENNER and ARTHUR SCHLAEPFER. In order that surface tarring may be successful it is necessary that the roads to be so treated be either in a very good state of preservation or previously resurfaced with new stone. The proper time for the application of the tar coating is from four to six weeks after the rolling of the new surfacing. It is essential, in all cases, that the surface be perfectly dry and free from dirt or dust and that the tar to be used should be as free as possible from water and ammonia. The first coating of tar should be applied only during dry weather, and, if possible, after several warm, sunny days. For a second coating a long period of warm weather previous to tarring is not so essential. Before the tar coating has become quite hard, it should be covered with a coarse sand and then rolled with a hand roller.

United States. WALTER W. CROSBY. In 1907 the City of Annapolis employed Tarvia on about 8,600 square yards of street surface. The macadam was laid in exactly the same manner as if it were ordinary water bound construction. After thoroughly rolling and watering the surface was left to dry. Then the macadam was well swept, and heated Tarvia was applied through a hose and spread by means of hand brooms, a wave of material being pushed over the surface. About ½ gallon of Tarvia per square yard was used. Later the absorbent spots were filled with enough additional bituminous material to give a uniform coating of ¼ of an inch over the macadam. A 1 inch coating

of chips, ¼ of an inch to ¾ of an inch in the longest dimensions, was then spread evenly over the tarred surface and rolled. The surface later presented an appearance similar to an asphalt pavement. There was no dust except when the removal of foreign matter brought on by the traffic was delayed. This treatment gave excellent results for about two years, at which time another light application of Tarvia was made in a similar manner. It is hoped that this last application will last longer than the first. The penetration of the tar into the macadam appeared to be from 1½ to 2 inches.

Later, work along the same lines gave either similar or better results. Considerable difficulty was encountered in securing a satisfactory bituminous material, the main defect of most of these refined tars being the tendency to lose their life and become brittle at too early a period.

United States. Austin B. Fletcher. In 1908 and 1909 a number of miles of State Highway were treated by the penetration method or by the mixing method. The work seemed to demonstrate that a sealing coat of bituminous material was necessary in both methods. Both of these methods were too expensive for extensive work in resurfacing old roads, and so the Commission adopted on a large scale the process of surface treatment. The road is first patched and rolled to secure as true and even a surface as possible. All the surplus dust is then swept off, usually with horse drawn sweepers, and the exposed surface is cleaned as well as possible. The bituminous material is applied by gravity distributors or by spraying machines at a rate of ¼ to ½ of a gallon per square yard. A coat of sand, screened gravel, or stone screenings is immediately spread over the surface to absorb the surplus bituminous

material and the roadway is rolled with a steam roller. In 1909, 1,050,000 square yards were treated by this method at an average cost of 6 cents per square yard, using an average of 0.312 of a gallon of bituminous material per square yard. In all of the work so done about 90 per cent of the bituminous material used was an asphaltic oil, containing about 80 per cent of asphalt.

The refined tars supplied under specifications seem to have been uniformly good, and the specifications appear to be open to less question than those for asphaltic oil.

It is probable that at least one more year will need to elapse before it can be said conclusively that protective coatings of bituminous material as herein described will protect the roads at a reasonable cost. Such work as the Commission has already done during 1908 and 1909, however, seems to indicate that at least a partial solution of the problem has been reached by that process. There seems to be little doubt that a coating, when not less than ½ of a gallon per square yard of bituminous material is used, will last for two years with small expense for repairs under the traffic conditions to which the Massachusetts State Highways are now subjected.

The tars and the asphaltic oils appear to have given equally good results as protectors but it should be stated that the tar forms a much harder coating than does the oil, and one which is likely to be more slippery. In fact, there have been some complaints received that tarred roads are unsafe for horses. It is also apparent that neither tar nor oil should be applied to a macadam road, the crown of which is in excess of ½ of an inch to the foot. It is probable that much better results are secured where the crown is not in excess of $^1/_3$ of an inch to the foot, since so smooth a

surface as results from the use of either form of bitumen requires but little crown to shed the water which falls upon the road. The asphaltic oil, when applied as before stated, results in a rubber-like coating which gives a good footing for the horses and which does not become slippery except under unusual frost conditions. It is hoped by the application of these surface coatings to do away for an indefinite period with the necessity for resurfacing with broken stone.

If no wear is permitted to come upon the stones themselves, the only cost for maintenance will be that of restoring the surface coating which ought not, according to the Massachusetts experiment, to exceed 2.85 cents per square yard per year.

United States. S. Percy Hooker. Oiling of roads is carried out extensively in the State of New York. The oil is applied both cold and hot, and specifications for oils applied by both methods are in use. The surface of the road is brushed clear of dust and, after the oil is applied, it is covered with a ½ to ¾ inch layer of dustless screenings. Sand and gravel were first used for top dressings, but they were not satisfactory. About 100 cubic yards of dustless screenings are required to properly cover a mile of road in this manner and these must be constantly brushed back into the center of the road by the patrolman for a period of three to four weeks until compacted by traffic.

Cold oil treatment costs about $350 per mile, the oil costing from 4 to 5½ cents per gallon, and from 3,500 to 4,000 gallons being used. Although none of the roads treated in this manner have gone through a winter, the writer thinks that the second year treatment will require less oil than the first, and that after three or four years, a treatment for one year might be omitted entirely.

Hot oiling was done with an Aitken's machine and one manufactured in New York. The comparative cost of applying hot oil is increased by the greater cost of the machine with which the oiling is done. When hot oil has been applied upon a newly finished road bed it forms a blanket that may be lifted away from the surface unless the screenings have first been thoroughly brushed from the road, leaving the stones in the top course exposed. The writer considers that two applications of cold oil upon successive years will cost approximately the same as one application of hot oil and will be more satisfactory.

The writer also believes that there is a tendency on the part of any tar product, when used on the road surface, to harden and cake, leaving a crust which is not a constituent part of the road. This crust will break through in places and will not heal, since, after hardening once, a tar product seems to lose its elasticity and stickiness.

United States. John R. Rablin. Gravel roads, in the construction of which a clay binder has been used, have been built extensively for the parkway drives. They have given very good satisfaction except that, at the season of the year when the frost is coming out of the ground, they are liable to rut if the amount of clay binder is at all excessive. To overcome this objection and to retain the gravel surfaced type of roads for the parkways, the writer has been using for the last two years a crushed stone base about 4 inches in thickness with a 2½ to 3 inch layer of binding gravel on top. After the completion of the surface and before it has become too hard to readily absorb the material, a treatment of heavy asphaltic oil, about 1 gallon per square yard, is applied, which serves to make the surface dustless and in a large measure to preserve it. The

most suitable oil to be used has been determined by the actual use of various grades of oil on the roads. The writer believes that on roads having a light traffic, including automobiles, one application every two years will suffice and that on roads having a fairly heavy traffic an application may be required each year.

A large portion of the macadam roads of the park system have been treated with a surface application of refined tar, which has served to protect them and keep them in good condition up to the present time, whereas otherwise they would have been destroyed. One objection to this treatment with tar is its slipperiness for horses in cold weather, but by the use of coarse, sharp stone screenings up to ¾ of an inch in size with the tar coating, this is overcome to a large degree.

United States. Charles W. Ross. The writer has found that a heavy asphaltic oil worked into the surface of the road prolongs the life of the road, makes it dustless, free from mud, and non-slippery. Before the oil is applied it is thoroughly mixed with sand heated from 150 degrees to 175 degrees Fahrenheit, the proportions used being 1 cubic foot of sand to 1 gallon of heavy asphaltic oil. The mixture is then spread on the street with shovels, raked with a fourteen-tooth wooden lawn rake and allowed to be compacted by traffic. During the construction of the surface it is not necessary to close the streets. It has proved very satisfactory and one treatment a year seems to be sufficient. After the first year the expense is much less, as the material has worked into the surface of the road making it nearly waterproof.

CHAPTER XI

BITUMINOUS PAVEMENTS]

Blanchard, Arthur H., M. Am. Soc. C. E., *Deputy Engineer, Rhode Island State Board of Public Roads*, Providence, R. I., U. S. A.

Bredtschneider, August, *Commissioner of Public Works*, Charlottenburg, Germany.

Cattaneo, Paolo, *Engineer, Office of Municipal Engineer*, Milan, Italy.

Crompton Col. R. E., M. Inst. C. E., *Royal Automobile Club*, London, England, Great Britain.

Crosby, Walter W., M. Am. Soc. C. E., *Chief Engineer to the Maryland Geological and Economic Survey*, Baltimore, Maryland, U. S. A.

De Jaegere, Alberic, *Civil Engineer*, Antwerp, Belgium.

Drummond, Robert, *County Surveyor, Renfrewshire*, Paisley, Scotland, Great Britain.

Eisenlohr, *Director, Board of Public Works*, Strasburg, Germany.

Fleck, Georg, *Commissioner, Board of Public Works*, Dresden, Germany.

Franze, Gustav, *Commissioner of Public Works*, Frankfort-on-the-Main, Germany.

Henning, John, *Imperial Commissioner of Public Works*, Oberlahnstein-on-the-Rhine, Germany.

Hörburger, *Member, Board of Public Works,* Munich, Germany.

Le Gavrian, P., *Engineer of Bridges and Roads,* Versailles, France.

Parker, Harold, M. Am. Soc. C. E., *Chairman, Massachusetts Highway Commission,* Boston, Massachusetts, U. S. A.

Pine, James A. W., *Consulting Engineer,* New York City, U. S. A.

Rablin, John R., M. Am. Soc. C. E., *Chief Engineer, Metropolitan Park Commission,* Boston, Massachusetts, U. S. A.

Saunier, Honoré, *District Inspector,* Rouen, France.

Schlaepfer, Arthur, *Street Inspector,* Zurich, Switzerland.

Sperber, *Chief Engineer,* Hamburg, Germany.

Warren, George C., *President, Warren Bros. Co.,* Boston, Massachusetts, U. S. A.

Wenner, Victor, *City Engineer,* Zurich, Switzerland.

Belgium. Alberic De Jaegere. The method of laying asphalt pavements does not differ essentially from the method employed in France and Germany. Powdered rock asphalt is the usual material employed. The average cost including the concrete foundations is $2.59 to $2.74 per square yard.

France. P. Le Gavrian. There has been little tar macadam constructed in France. There is, however, about to be undertaken on a large scale the commercial manufacture of tarred material. The results from the trials with

tar macadam constructed with various road metals have given mediocre results. Tar macadam, while undoubtedly more costly than poured macadam, will always have the advantage over the latter in that the tar is more evenly distributed between the stones thus giving homogeneity, which quality is of paramount importance to all good roads.

A process known as pitch macadam has been employed. This method consists of mixing pitch and sand together and spreading this mixture on the road during the process of compacting and later applying oil to reduce the pitch to a kind of tar. The trials were too recent for the formation of any definite opinion as to the merits of the process, although borings showed that the oil had penetrated ¾ of an inch to 1¼ inches and had made the pitch more or less plastic. The process only costs from 6½ cents to 9½ cents per square yard above the cost of ordinary macadam.

A combination of tar, soap and clay mixed with the road metalling before rolling has given only mediocre results.

Tarvia, a patented English product, has been employed by spreading a hot mixture of fine gravel and Tarvia over the old road, covering this layer with the road metal, and later applying another Tarvia mixture. At the time of writing the results could not be ascertained definitely.

Trials made of placing metalling on tar, previously applied cold to the surface of old roads, have not proved to be superior to ordinary surface tarring.

Tar has been applied by the penetration method both in a single process and by the application of several layers of tar, good results having as a rule ensued.

The writer has employed a system consisting of small broken porphyritic stone varying from ¼ of an inch to 1½ inches

in dimensions coated with a mastic of asphalt and sand, and spread in a layer of 1½ inches to 2 inches in thickness. In this manner a very close grained macadam is obtained, the interstices of which are filled with mastic. The application was made in August, 1909, in Versailles upon the road to Paris where there is a very heavy horse drawn vehicle traffic, composed chiefly of the household refuse carts going to the road depots of the city.

The results have been excellent, both in winter and in summer. The frosts, it is true, were not severe last winter and have not damaged in any way the asphalt surfacing, which has maintained itself up till now in a perfect condition, whereas the metalled and tarred sections of the roads have suffered during the bad weather. The results have been so encouraging that the Minister of Public Works has authorized the continuation of the trials and has granted the writer the necessary funds for this purpose. A new application will be made this month. According to the preliminary trials, with which the author has been occupied lately with a view to ascertaining the quantities and to improving the methods of construction, he has arrived at this conclusion: that this macadam laid as a bed 2 inches in thickness will not cost more than 64 cents to 72 cents per square yard with the materials in our district, the porphyritic stone costing $2.97 per cubic yard and the asphalt mastic costing $14.00 to $15.75 per ton. If the good results attained up till now are confirmed, a road surfacing will have been obtained intermediate between the macadam and the stone block pavement both as regards resistance and price.

France. Honoré Saunier. The following experiments with the Bedeau system of construction were carried out. Several days before the laying on the road, stone,

clay and tar were mixed in proportions of three wheelbarrows of stone, one wheelbarrow of clay, and 2.9 gallons of tar. The stones were wet previous to mixing with clay. After consolidating this coating by rolling, a surface coat of tar was applied. The appearance of the road after completion was not different from that of ordinary macadam. In another experiment galgatine (tar and clay mixed in barrels in a proportion two to one, with a little water) was brought to the road and mixed with stone in the proportion one to twelve. Sand and cement made into a mortar was then mixed with the coated stone. This product was laid much the same as in the previous experiment except that a coating of sand was added instead of the tar coating. The road has always been muddy since construction. Apparently this system is not to be recommended.

Germany. JOHN HENNING. During the past two years about 135,000 square yards of bituminous pavement have been laid. Machine mixing has been found to be the only method of work which assures good construction. Six different types of mixing machines, including both batch mixers and continuous mixers, are used in Germany.

Germany. SPERBER and GUSTAV FRANZE. For successful construction by the mixing method, the road metal should be perfectly dry and warm, the tar should be hot, and the process should be carried out only in dry weather. This method of construction is not used extensively in Germany, but some of the trials are interesting. The material employed is usually refined tar or tar mixed with a certain amount of asphalt cement. Poor results by this method are often obtained due to rolling while the tar is wet or after it has set up. Realizing this, Aeberli has de-

vised a method of making tar take the form of soft pitch. The following is a description of this method.

The perfectly dry and well heated road metal is completely impregnated with hot coal tar (Aeberli states 35 degrees to 40 degrees Centigrade), and is then placed in heaps and well covered with sand. The road metal is allowed to remain in this condition for about three weeks. During this time the soft pitch referred to, which possesses very great adhesion, is formed. A layer of pitch coated road metal 3 inches to 5½ inches thick is then well rolled and exposed for three or four days to the action of the air and sun. During this time hard pitch is formed, so that a thoroughly close and firm layer of road metal is obtained owing to the faces of the stone adhering firmly one to another and to the soft pitch hardening into hard pitch. Aeberli then rolls on this bed of road metal a moderately thick layer of small stone 1¼ inches to 2 inches in size, treated in a similar manner. Exceedingly good results have been obtained with this method, and it would be well to test it on a larger scale.

The so-called penetration method has been employed frequently, although the general opinion seems to be that surface tarring after six or eight weeks is fully as good, provided the traffic is not too severe.

The stone has, in a few cases, been mixed with bituminous material on a mixing board or, as in one case, by employing a concrete mixer. In two towns coating the road metal has been accomplished by submerging hot stone in cold tar, while in other cases, cold stone has been submerged in hot tar.

Germany. August Bredtschneider; Hörburger; Eisenlohr and Georg Fleck. The material employed in

the construction of asphalt pavements is generally a ground bituminous limestone containing between 9 and 13 per cent of bitumen. The asphalt surface is laid on a concrete bed about 10 inches thick. Old asphalt pavement has recently been reground and mixed with sand and Trinidad asphalt to form a new wearing surface. This method is stated to be comparatively inexpensive.

A pavement consisting of slabs of from 1½ inches to 2 inches in thickness with faces from 6 inches to 8 inches square, made of asphalt powder under heavy pressure, has been in use for a considerable time in the west and south of Germany. The plates are laid in cement mortar or bitumen on a smooth concrete bedding 8 inches thick. Slab pavement of this kind laid on the carriageway behaves much like a rammed asphalt pavement. In some of the south German towns use is being made experimentally of vulkanos slab pavement consisting of hard stone metalling and a suitable cement which is subjected to high pressure and a twelve day burning process. The slabs are about 3 inches thick by 10 inches square, and are laid in cement mortar on the concrete base.

Great Britain. Col. R. E. Crompton. The method of laying a graded aggregate mixed with tar, the writer considers superior to surface tarring and is a method bound to become common in England. Such a surface costs not over 37 cents per square yard in England, and from experience already obtained, it is believed that such a surface will last from six to ten years. The usual method employed in England in this construction is to excavate the old road surface to a depth of about 3 inches and bring the new surface up to the old grade by application of the tarred aggregate. The cross-fall of such a road need not exceed 1 in 50. It is

a mistake to roll the layer of tarred aggregate with a roller weighing over 11 tons. It is advisable to apply every year or every alternate year a light coat of tar to such a surface in order to ensure waterproofing.

Great Britain. ROBERT DRUMMOND. One system of constructing a tar macadam road in England is as follows: the method of application is similar to applying an ordinary coating of metal, except that before application the surface of the road should be prepared by scarifying, levelling all inequalities and rolling it smooth. The tarred stone of the required thickness is then applied and rolled with a steam roller and bound with a light coating of tarred chippings. Under proper conditions this method makes an excellent roadway, and gives it a very much longer life than any form of approved macadam surface. Taking everything into consideration this system is as cheap as any of the other systems, and gives much better results. It is only the question of the initial expense which prevents this method from being more generally adopted. The additional cost of tarring the stone, and binding it with tarred chippings is about 10 cents per superficial yard.

Italy. PAOLO CATTANEO. The method of constructing asphalt pavements in Italy is as follows: on a concrete foundation, laid on solid ground which is not likely to settle, the asphalt is spread in the form of powder heated to a temperature of 100 degrees Centigrade. The powder, which is obtained from the pure mineral, must be homogeneous and free from any foreign substance. It must contain at least 10 per cent of bitumen. Next, the thickness of the soft layer must be reduced from 3¼ inches to 2 inches by artificial compression by means of hot tools. The smooth surface is at the same time

slightly sprinkled with cement, the object of which is to fill up the small holes on the surface. The street can be opened for traffic in twenty-four hours after the work is finished.

Switzerland. VICTOR WENNER and ARTHUR SCHLAEPFER. Together with stone paving, asphalt decidedly takes the first place among hard surfacings in Switzerland, rammed asphalt being principally employed for carriageways, and asphalt mastic almost exclusively for footways. The foundation always consists of a concrete layer, which in carriageways where traffic is light is 4 inches thick, built directly on a well drained and thoroughly consolidated road. For heavier traffic the concrete has a stone foundation of 6 inches to 8 inches in depth. With rammed asphalt the gradient of the road may reach 2 per cent, a greater incline rendering the pavement too dangerous for traffic on account of slipperiness.

Asphalt plates, 12 inches by 4 inches by 2 inches, made under heavy hydraulic pressure, are also used to some extent. Diplolith concrete plates 10 inches square and 2 inches thick are laid on a bed of lime concrete, and on these is laid a ½ inch layer of asphalt powder applied under heavy hydraulic pressure. Both of these types of pavement, however, are suitable only for light traffic.

United States. ARTHUR H. BLANCHARD. The State Board of Public Roads of Rhode Island built its first section of bituminous macadam pavement in 1906. The construction of this section consisted of placing on a firmly compacted subgrade a 6 inch layer of crushed stone varying in size from 1¼ inches to 2½ inches. After this course was thoroughly rolled about ⅕ of a gallon of hot coal tar per square yard was spread on the surface. The stone

for the surface course, varying in size from ½ of an inch to 1¼ inches, was next deposited on a mixing platform and thoroughly mixed with hot tar by using rakes and shovels until every stone was completely coated. This mixture was laid on the bottom course to a depth of 3 inches and rolled to 2 inches. Finally a thin coat of ½ inch screenings was spread on this surface and rolled. The tar used was a crude coal tar from the Providence Gas Company. The total quantity used was 1¼ gallons per square yard. In this case no flush coat was added, since motor vehicles composed 90 per cent to 95 per cent of the total traffic. When inspected in October, 1909, the road was in as good condition as when laid.

In 1908 several experimental sections were laid, one by the penetration method, the rest by the mixing method as constructed in 1906, except that in some cases the coating of the bottom course of stone with tar was omitted. The bituminous materials used were a crude coal tar, a refined coal tar, a mixture of crude coal tar and Texaco asphalt Grade H, 50 per cent of each, a mixture of crude coal tar and coal tar pitch, 75 per cent and 25 per cent of each respectively, and Texaco asphalt grade H. The stone was mixed by hand on mixing platforms. Crude coal tar was used as the binder for the stretch built by the penetration method. This binder was applied by means of dippers, 1.87 gallons per square yard being used. In the case of the experiment where the Texaco asphalt grade H was used alone as the binder, mixed with cold stone, an excessive amount of binder was necessary in order to partially coat the stone, a total of 3.59 gallons of asphalt being used per square yard. In the other experiments 1¼ gallons of bituminous material were used per square yard. The cost per

square yard in excess of the cost of ordinary macadam construction was 14.3 cents for the experiment built by the penetration method, 40.1 cents for the experiment where asphalt was used alone as the binder, and from 12 to 15 cents for the other experiments. The variation in cost depends largely upon the kind and amount of the binder used.

This road is subjected to a very heavy motor car traffic in the summer months and a very limited horse drawn vehicle traffic. An examination of the sections in 1909, after they had been used two summers and one winter showed that very good results had been obtained. There was no apparent difference between those sections in which the bottom course had been painted and those in which this operation was omitted. The section constructed by the penetration method showed slight disintegration in spots, due probably to an uneven application of the binder or to the segregation of the smaller sizes of stone in the surface course, thus preventing sufficient penetration to secure the requisite bond.

One section built in 1908 by the mixing method was constructed with a crude coal tar from the plant of the Attleboro Gas Gompany. This tar was not as good as that of the Providence Gas Company, which was used in all other cases. Practically all of the 1,000 feet, in which the Attleboro tar was used, disintegrated and had to be repaired before the end of the season by painting the entire surface with about one gallon per square yard of Texaco asphalt. This section was subjected to a heavy motor car traffic and a very limited horse drawn vehicle traffic.

One section of 2¼ miles was built on a trunk line which is subjected to both excessive motor car traffic and excessive

horse drawn vehicle traffic, there being about 50 per cent of each. At the beginning of the work a section 2,000 feet in length was built by the mixing method, Providence coal gas tar being used as the binder. Before the end of the 1908 season this section commenced to disintegrate due to the impact of the sharp calks of horses' hoofs on the exposed stone in the surface course. This section had to be repaired early in 1909 by applying a flush coat of tar to the surface and then a flush coat of asphalt, covered with a layer of chips. The remainder of the 2¼ miles was finished with a flush coat of bituminous material, 0.6 of a gallon being used per square yard, in order to provide against the disintegration caused by the impact of the horses' feet. The greater part of the road was built by the mixing method, using in the mix 1¼ gallons of bituminous material consisting of 50 per cent of Texaco asphalt grade J and 50 per cent of crude coal tar, with either a flush coat of Texaco asphalt grade H or crude tar. With the approach of cold weather crude tar was used alone in the mix and Texaco asphalt for the paint coat. In the latter part of November, crude tar was used for both the mix and the paint coat. During 1909, these various sections needed only slight repairs and in October, 1909, the sections which had been given a flush coat of asphalt were almost faultless. The cost of these sections in excess of the cost of ordinary macadam construction varied from 17 cents to about 21 cents per square yard.

From the results obtained in 1908, it was decided in 1909 to adopt as the standard a bituminous pavement constructed with 50 per cent of Texaco asphalt and 50 per cent of Providence tar for the mix, and a flush coat of tar. Later in the season an asphalt flush coat was substituted

for the tar. From 1¼ to 2 gallons of material per square yard were used in mixing the stone, while the amount used for the flush coat varied from 0.6 to 1 gallon per square yard.

During the months of September to October, 1909, several experimental stretches were built using refined materials. The work was done by the hand mixing method. In each experiment the surface was treated with a flush coat of the same material as was used in the mix. The bituminous materials used were a refined water gas tar, two grades of refined coal tar, two grades of prepared mixtures of refined coal tar and asphalt, and a so-called 85 per cent asphaltic binder. In connection with some of these experiments the tar coating machine of the American Tar Company was used.

United States. Walter W. Crosby. In 1909, Park Heights Avenue, Baltimore, was treated by the penetration method. The old macadam surface was scarified to a depth of 2 inches and sufficient new stone, varying in size from 1 to 2 inches in their longest dimensions, was added to give the desired crown. The stone was well rolled in order to reduce the voids. It was estimated that twice the ordinary amount of rolling was done. The binder was applied hot (80 degrees to 150 degrees Centigrade), and in most cases so as to completely fill the voids in the stone. The amount of material used varied from 5 gallons to 1½ gallons per square yard. Stone chips were spread over the freshly tarred surface to a depth of from ¼ to ¾ of an inch and then rolling was undertaken as soon as convenient. Later any excess binder was dusted with clean sand. Ten different materials were employed, including various coal tar prep-

arations, refined water gas tar, and heavy asphaltic compounds.*

It is too soon to report on the success of this work but a narration of some of the incidents connected with it and the results secured to date may be of interest.

Material number one was an asphaltic compound. It was expected to use about 2 gallons of binder per square yard and it was found that this amount was just about what the voids of the rolled stone would hold. This material, however, had a tendency to rise through the stone and screenings. Repeated applications of sand were used on these places with the result that in some instances there now exists a carpet of sand and bituminous material on the road to a depth of 1½ inches over the stone. Although this carpet did not pick up, it was noticed that the resistance to traction was greatly increased, especially during the warmer hours of the day. These effects, apparently due to an unnecessary excess of the binder, gradually decreased with age and are at present (November, 1909) practically unnoticeable although they may reappear next summer. The use of 1¾ gallons of material per square yard, instead of 2 gallons as at first, considerably reduced the annoyances above described.

Material number two was an asphaltic compound considerably more fluid than number one, which made it difficult to fill the voids near the crown of the road without a considerable loss of material at the sides. On account of its fluidity 3½ gallons of binder per square yard were used. This material appeared to rise to the surface to a slightly greater extent than number one. Otherwise the results seem similar to those obtained with material number

* A table of the analyses of these materials is given on page 70, Chapter V.

one, except material number two does not set as quickly nor as much.

Material number three was an asphaltic compound much more viscous at normal temperatures than either number one or number two. It did not waste at the sides as did those others, nor did it give nearly as much trouble by rising to the surface. It set much more readily and the usual results seemed much more satisfactory. About 3 gallons per square yard were used.

Material number four was a refined water gas tar. Two grades were used, one of which had a somewhat lighter consistency than the other. Results so far seem similar to those where material number three was used. About 3 gallons were used per square yard.

Material number five was supposed to be a refined coal tar. This material was slightly less fluid than material number four. About 3½ gallons per square yard were used.

Material number six was a refined coal tar of about the same consistency as material number two. About 5 gallons per square yard were used.

Material number seven was a refined water gas tar. Although it appeared to be altogether too fluid for satisfactory use, it was used since a similar material had been successfully tried out in 1908. Afterwards it was found necessary to paint all but about 1,000 square yards of the work with the lighter grade of material number four. Investigation showed that although the same processes for the manufacture had been followed as had been carried out in making the 1908 tar, a change in the character of the oil used by the gas works in carburetting the gas resulted in a totally different refined tar for road use. Con-

sequently the further use of this particular material was abandoned.

All of the tars with the exception of number seven gave results that so far seem about the same and quite similar to those where material number three was used. They were more adhesive than materials numbers one and two. They set quicker and do not give nearly as much trouble from rising to the surface or wasting out at the sides. Generally speaking, the refined coal tars were the easiest to apply as they reach a greater fluidity at a moderate degree of heat, but some complaints of excessive slipperiness in cold weather have been received on the section where material number four was used.

Material number eight was a heavy binding oil, in appearance similar to number two. Its action and results so far have been almost identical with the same material. About 3½ gallons per square yard were used.

Material number nine was a refined coal tar of about the same consistency as material number five. About 4 gallons per square yard were used.

United States. Harold Parker. An experimental section of resurfacing an old macadam road using gravel and an asphaltic oil mixed with pure bitumen, or an oil with a very large percentage of asphalt, was constructed by the Commission. The road so constructed was previously macadamized in 1900, and was badly worn. The surface was picked up by a steam roller, and reshaped. The rolling of this reshaped surface was not very severe, since it was desired to have the stones rather loose so that the crawling of the top coat would be prevented. The oil and asphalt were heated separately to about 300 degrees to 400 degrees Fahrenheit, and the sand to about 225

degrees Fahrenheit. The latter was thrown on thin iron smoke stacks to a depth of about 1 foot and heated by wood fires. The mixing was done by hand, first on wooden platforms, and later on steel with better results. After measuring the sand and gravel by means of a measuring box, about one-third of the required quantity of hot oil was applied in small quantities and the mass turned over once, next the full amount of oil was added and the mass turned again, finally the entire amount of asphalt was added and the entire mass was turned until thoroughly coated. The mixture was then carted to the road and was either shovelled directly onto the ground or placed on dumping boards, the former method proving the better since there was less cooling of the material. After a careful spreading, the surface was rolled gradually as the material cooled and hardened. Although a 10 ton roller was used, the writer believes a 5 to 6 ton tandem roller would have worked better.

Seven experiments were made. About 18 gallons of binder were used per cubic yard of gravel. In two experiments asphaltic oil was used as the binder and in the others varying percentages of asphaltic oil and pure asphalt. Both the asphaltic oil and the oil asphalt were required to conform to specifications. The gravel was screened to different sizes and was mixed with sand that would pass through a ¼ inch screen, different proportions of each being used.

To obtain perfect results, teaming should be kept off the road for a period which need not be longer than twenty-four hours after spreading.

The conclusions reached were that all of these trials appear to be successful; that where the traffic is heavy,

asphalt should be added proportionally. For ordinary use, however, asphalt oil without the addition of asphalt, mixed thoroughly with gravel composed of particles not larger than would pass through a ½ inch screen, will produce a road that will withstand the wear of automobiles and other traffic in a satisfactory and economical manner.

United States. James A. W. Pine. The writer believes if a suitable bituminous cement is found, that the nearer the proportions of bituminous cement, sand and stone follow the present practice in proportioning hydraulic cement concrete, the better will be the pavement. If hot liquid asphalt cement is used it should be first mixed with the hot sand or mineral matter, and then the large stone, heated to about 300 degrees Fahrenheit, should be added. Either hand or machine mixing may be used.

The writer condemns the penetration method since uniformity cannot be obtained. More bituminous cement is required for this method and it cannot be distributed evenly. Moreover the contraction of bituminous concrete, after having been put in place while hot and after tamping or rolling, tends to make the resulting pavement more solid. This advantage, of course, cannot be obtained by the penetration method.

A method suggested for using Trinidad asphalt is to pulverize the crude asphalt and then subject the granulated material to simple evaporation to rid it of water. These operations can be done at a trifling cost and the product may be shipped in bulk or bags for delivery direct on the work where, without the aid of any special melting apparatus, it can be mixed cold with the previously heated mineral matter, and flux.

United States. John R. Rablin. Some of the roads of the Metropolitan Parkway system have been constructed by the penetration method. The bituminous material is applied, at a temperature from 150 degrees to 200 degrees Fahrenheit, to the top course of stone after it has been thoroughly rolled. The surface is then rolled again after which a flush coat of bituminous material is applied by brooms, by spraying, or by some other form of distributing machine. This surface is covered with good stone screenings and rolled. Very satisfactory results have been obtained by this method. About 1½ gallons of refined coal tar per square yard are generally used for the first application, and a mixture of refined tar and residual asphalt, containing about 10 per cent of asphalt, is used for the flush coat. The object of the asphalt being simply to prevent the tar from becoming brittle and hard and hence slippery under traffic. The writer believes that the use of a clear asphalt is advisable for use as a flush coat even if the cost is increased.

United States. George C. Warren. The small investment in plant necessary and the very cheap method of application are two points in favor of the penetration method. The disadvantages of this method are the insufficient coating of the road metal, owing to the inability of the bitumen to thoroughly penetrate small voids; the ravelling of the road if the bitumen used is not hard or cementitious enough; the poor cohesive results attained if the voids are not completely filled with bituminous material; the consequent oozing of the material to the surface under traffic in hot weather if sufficient material is used to fill the voids.

Hand mixing is, as a rule, cheaper than machine mixing because there is no expense for plant installation and no fuel

cost, which makes it especially adapted to small contracts. There is a tendency to use a softer bitumen with this method in order to secure greater ease in mixing. The less accurate proportioning and distributing of materials and the inability to get as thorough a mix are also disadvantages of this method.

Mechanical mixers such as the ordinary concrete mixer, either of the continuous or batch type, may be used without much expense if the ingredients are not heated. In such a case, however, the disadvantage of using a bituminous material so soft as to be liquid at normal temperature is very great. Mixers which heat but do not proportion the materials are better but still defective.

The proper mixing machine to use is one which is specially designed to heat the materials and which will give a uniform and accurate proportioning of both bituminous material and stone. It should have heating power enough to permit the use of a bitumen hard enough to act as a true binder. It should produce a mixture which, when compressed on the road, will be dense enough to prevent penetration of moisture and will be strong enough to resist all classes of traffic.

The writer believes that the necessary essentials to the best construction are:

1. That the sizes of stone or mixture of stone and sand composing the mineral aggregate of the wearing surface shall be scientifically and accurately proportioned, varying from the coarsest size permitted by the thickness of the surface (at least ½ of an inch less than the depth of compressed surface desired), down to an impalpable powder, each size so proportioned as to reduce the voids to the greatest practicable extent, which in practical work can be as low

as 10 per cent to 15 per cent of the volume. To practically produce this result a mixing plant designed to proportion and control the sizes of the aggregate is essential.

2. That sufficient bitumen shall be used to thoroughly fill the remaining voids and evenly but thoroughly coat every particle of aggregate, large and small, with a thin coating, of bituminous cement. By using a bituminous material of the proper grade and with thorough compression, a solid construction of bituminous concrete is obtained. This concrete is within 5 per cent of the specific gravity of solid rock of the character used in the wearing surface. This difference in specific gravity represents the difference between the specific gravity of the stone and the bitumen used in the construction, and not voids or lack of density or stability in the compressed bituminous concrete wearing surface.

CHAPTER XII

BRICK, CONCRETE. STONE BLOCK AND WOOD BLOCK PAVEMENTS

BRADACZEK, THEODOR, *Imperial Commissioner of Public Works*, Prague, Austria.

BREDTSCHNEIDER, AUGUST, *Commissioner of Public Works*, Charlottenburg, Germany.

DE JAEGERE, ALBERIC, *Civil Engineer*, Antwerp, Belgium.

EISENLOHR, *Director, Board of Public Works*, Strasburg, Germany.

FLECK, GEORG, *Commissioner, Board of Public Works*, Dresden, Germany.

FOCK, EDOUARD, *Chief Engineer*, Budapest, Hungary.

FROIDURE, EUGÈNE, *Principal Engineer of Bridges and Roads*, Ypres, Belgium.

GLASNER, ANTOINE, *Engineer*, Budapest, Hungary.

GUIET, SAMUEL, *District Inspector*, La Roche-sur-Yon, France.

HÖRBURGER, *Member, Board of Public Works*, Munich, Germany.

LAFARGA, PROSPERO, *Engineer of Highways, Canals and Harbors*, Alicante, Spain.

LE GAVRIAN, P., *Engineer of Bridges and Roads*, Versailles, France.

MENCZER, BELA, *Chief Engineer*, Budapest, Hungary.

SCHLAEPFER, ARTHUR, *Street Inspector*, Zurich, Switzerland.

VAN LÖBEN SELS, M. J., *Vice-President, Netherlands Association of Brick Manufacturers*, Nimwegen, Netherlands.

VERSTRAETE, RICHARD, *Engineer of Bridges and Roads*, Bruges, Belgium.

WENNER, VICTOR, *City Engineer*, Zurich, Switzerland.

Austria. THEODOR BRADACZEK. The localities where pavements are employed are for the most part those stretches of the Imperial Roads that pass through the towns and are maintained by the communities.

The pavements usually consist of granite cubes, but in many places they are made of the round topped stones popularly known as cobblestones. The replacement of these old fashioned cobblestones with cube block or kleinpflaster is desired. To this end a state contribution is made to the communities of as much as 30 per cent of the cost of a strip 21 feet in breadth, on the condition that they maintain the pavement in return. In places where there is no very heavy vehicle traffic, kleinpflaster may with advantage be applied for repaving. The old paving stones are turned up on end, laid deeper to act as a foundation, and rolled. The inequalities are remedied by a layer of concrete. The kleinpflaster is laid over this layer on a thin bed of sand and rammed down.

Belgium. ALBERIC DE JAEGERE. Stone block pavement:—The paving blocks are laid with the longest dimensions at right angles to the direction of traffic, the usual foundations consisting of a sand bed 4 inches to 6 inches

thick. At Antwerp where the traffic is intense, a ballast foundation 12 inches thick is employed. Upon this foundation is spread a 2 inch bed of sand to serve as a cushion layer for the blocks. Porphyry, sandstone, and Swedish granite are the materials employed for making the stone blocks. Porphyry is very hard and long lived but blocks made of it become slippery with wear, while sandstone costs less than porphyry but wears more rapidly. Swedish granite blocks are very satisfactory. They are long lived and do not become slippery.

Wood block:—Wood pavement blocks usually have about the following dimensions: thickness, 3¼ inches; width, 3 inches; length, 8¾ inches. This type of pavement is laid in the following manner: A bedding of fine cinders is laid 4 inches thick, well compacted and watered, on which is spread a layer of macadam 6 inches thick. This layer of macadam and metal is watered, compressed and rolled so as to reduce the thickness to about 5 inches; the upper surface is dressed to the final camber of the road cross-section. The wood blocks are first dipped for fifteen minutes in a bath of boiling tar, composed of heavy oil or creosote, with the addition of ⅕ part of tar, and then laid in a bed of Rhine sand ¾ of an inch in thickness which was previously well watered. On each side along the foot pavement curb, there is left a space of 1¼ inches in width which is afterwards filled with clay. On the top surface a dressing of hot tar is spread, and on this a thin layer of fine gravel. Finally this latter operation is periodically renewed to preserve and maintain the surface.

Brick pavement:—Another system of paving used at Brussels consists of a pavement of tarred bricks. This pavement has been laid on a concrete foundation 4 inches

thick, composed of a mixture of 0.92 cubic yards of gravel and 551 pounds of cement. The bricks are the kind called "Straat Klinkaert," and are submitted to a preliminary heating in order to obtain complete dryness. They are then plunged for three hours into a tar boiler, containing a boiling mixture of creosote with $^1/_5$ part of tar added. As in the case of wood pavement, the surface is afterwards coated with tar and fine gravel. The tar has the effect of making the bricks more elastic and more resistant. Moreover, a pavement with tarred bricks is much less slippery than wood pavement.

Concrete pavement:—A concrete road is a macadam in which the binding material is cement. Unfortunately cement wears off and produces a disagreeable dust. The writer is of the opinion that slabs constructed of various ingredients mixed with cement will never equal natural materials in hardness or life.

Belgium. EUGÈNE FROIDURE and RICHARD VERSTRAETE. In 1906 the experiment was tried of brushing into a rolled metal surface a mortar of cement and sand. Rolling was also carried on at the same time to aid in the penetration of the mortar. The results were satisfactory and further application of this process will be made. Another interesting form of construction tried in Belgium is that of placing between two layers of road metal a layer of slag mortar. Upon rolling, this bed of mortar penetrates into both layers. These roads have worn well. The mortar which is considered best for the purpose consists of 10 parts of fresh granulated slag, 2 parts of hydraulic lime and 1 part of slow setting Portland cement.

France. SAMUEL GUIET. The writer has developed a process known as "Reinforced Macadam" which consists

of a layer of cement concrete about 3 inches thick on which is placed a sheet of steel wire or expanded metal. This is covered by a layer of cement mortar, about 1½ inches thick, in which is placed by hand, face upward, stone metalling about 4 inches in size. This forms a monolithic road-covering, requiring no attention and is exceedingly durable.

As there are no joints in this pavement, there is no shock between one stone and the next, the noise being consequently very subdued and resembling the rolling of drums at a great distance. As to the want of elasticity, it suffices to say that since the advent of automobiles, elasticity is provided for in the wheel tires, and in the spring suspension of the chassis, which fact justifies the construction of monolithic roads.

Many trials with this form of pavement in places where the amount of traffic makes the upkeep of macadam impracticable have given satisfactory results. The pavement has the further advantage of being more economical than ordinary paving, and no more costly in the end than macadam, if all the factors which go to make up a road be carefully taken into consideration.

France. P. Le Gavrian. The method usually employed in the construction of mortar bound macadam roads is to mix hydraulic lime with sand, spread the mixture on the road, and then wash it in by sprinkling with water. The process is not to be recommended, since good results, as a rule, have not been obtained. The extra cost above ordinary metalling is about 5 cents per square yard. Cement has been used in three different ways: (1) Mixed with the road metal and spread with it at the time of rolling. (2) Spread at the end of operations either neat or mixed with sand, either as mortar or mixed dry and watered after

spreading. (3) As mortar mixed with the road metal. Cement is subject to the same faults in highway construction as is lime, there being a similar lack of elasticity as shown by the tendency to crack. Slag spread over well watered broken stone has given very fair results.

Germany. August Bredtschneider; Hörburger; Eisenlohr; and Georg Fleck. Stone block pavement:—The material used for stone block pavement is in a large measure obtained from local quarries and consists principally of granite, although carbonated sandstone, graywacke, porphyry, melaphyre, greenstone, diorite, quartzite, gabbro and basalt are also employed. Of the stone imported from abroad porphyry from Belgium and granite from Sweden are important. The stones employed are about 4 inches to 7 inches in breadth and from about 5 inches to 8 inches in height and are laid with the long dimension perpendicular to the direction of the roadway or in some cases diagonal. The bedding consists of ballast, although concrete laid to a thickness of 8 inches to 10 inches is sometimes used. The joint filler usually consists of bitumen, but in some cases cement mortar is employed.

Artificial stone pavement is similar to that with square dressed natural stones. This type consists for the most part of blocks whose top and bottom faces are about 6 inches square. By far the larger part of the blocks are made of copper-schist slag, but clinker is employed in very small quantities. The stones are laid in exactly the same manner as are the natural stone blocks used in square dressed pavement, partly with and partly without joint filling, and without solid bedding. The town of Leipsic has a comparatively large surface of carriageway laid with copper-slag stones. Clinker-stones have not proved satisfactory.

Kleinpflaster has come into vogue within the last decade. It consists of polygonally dressed stones of from $2\frac{1}{2}$ inches to 4 inches square, mostly of hard stone such as granite and basalt, but also of graywacke, porphyry and greenstone. It is used as an improvement over macadam, being laid in coarse sand after the removal of the upper parts of the ballast layer. It is in many towns coming more and more into favor. In Brunswick it covers a surface of 239,200 square yards.

Wood block pavement:—Wood block pavement has not been introduced into Germany to the extent which it has in France and England. The usual method of laying the pavement in Germany is to place the blocks directly on a concrete base 10 inches thick and fill the joints with cement grout or bitumen according as the wood is soft or hard respectively.

Concrete pavement:—Concrete pavement, such as the so-called Kieserling pavement, is intended to give a jointless surface like that made of asphalt. This pavement consists of a basalt stone concrete. It is laid to a thickness of 2 inches to $2\frac{3}{4}$ inches on the concrete foundation layer while the latter is still soft. It is provided with expansion joints. Kieserling pavement has been introduced into a number of towns.

Hungary. Antoine Glasner. The paved road is constructed in Hungary in two ways, as large standard pavement and as small standard pavement. A firm foundation is not so essential in the case of the large standard pavement as it is for the small standard pavement. In the former the stones are of such a size that they are not easily displaced, but in the latter form of pavement the traffic will quickly ruin the surface if the stones are not placed on a firm foundation.

In Hungary small standard pavement is usually placed at an angle of 45 degrees with the axis of the road. The roadway is first carefully shaped and rolled, and then the stones are placed on this surface as compactly as possible, after which the joints are filled with wet sharp sand. The road is then rolled with a steam roller until the stones cease to yield to the pressure. A thin layer of sand is then added. The stones used are about 3 inch to 4 inch cubes, usually having very regular surfaces. These pavements are elastic, easy under traffic, clean and practically impermeable to water, and are suitable even under fairly heavy traffic in towns. They also make a good foundation for a future stronger pavement.

Hungary. EDOUARD FOCK and BELA MENCZER. Stone block pavement:—Stone block pavement is laid as follows in Hungary: Blocks of three sizes are in general use, the full sized blocks measuring 7 inches by 7 inches by 7 inches, the three-quarter sized blocks measuring 7 inches by 7 inches by 5 inches, and conical shaped blocks measuring 7 inches square on the top face and having a bottom face of two-thirds the area of the top face. The customary foundation is composed of well rolled metalling. Concrete is not frequently used because it causes the road to lose its elasticity and also makes excavating for underground pipes, etc., a difficult proposition. The blocks are laid with their edges diagonal to the direction of traffic, experience having shown that the wear is less with this arrangement than with the method of laying them square with the direction of the road. The practice of pouring cement mortar into the interstices is not to be recommended. Filling the joints with clean sand has given satisfaction.

Wood block pavement:—The use of wood is limited

to the Capital, since the unfavorable results there obtained with this material do not encourage the provincial towns to adopt it. Hitherto pine and fir wood blocks have been used for wooden pavements. An experimental pavement with larch blocks has not yet been long enough in use to enable a definite opinion to be formed concerning it.

Netherlands. M. J. VAN LÖBEN SELS. Nearly two-thirds of the State Roads are constructed of brick with dimensions approximately 2 inches by 4 inches by 8 inches. In South Holland there are made bricks called "Rijnorm (Rhine Bricks)" which are smaller, and measure 1¾ inches by 3½ inches by 7 inches, as well as those of "Utrecht," which have the same dimensions as the "Rijnorm." These small bricks form excellent road surfaces, free from dust and mud, proving satisfactory in summer and in winter. The small bricks, "Rijnorm" and "Utrecht," are excellent for foot pavements.

In order that a brick paved road may be well made, it is first necessary to thoroughly roll the bed, as is the case in all other roads. This foundation is then covered with a layer of sand. The bed of sand having been completed, the bricks, taken one at a time, are laid as close as possible against each other in lines at right angles to the axis of the road and struck lightly with a paving mallet. Each consecutive line bonds the next by half a brick, or the bricks are laid in herring bone fashion. The brick roadway is curbed by a few longitudinal rows which form the gutter. After laying, the bricks are forced into the sand beds by means of tampers, and the joints are filled with sand by means of brooms. The whole road surface is covered for some time with a bed of sand about ¾ of an inch thick.

The following advantages are claimed for a brick pavement:

1. The maintenance is simple. A roadman of slight intelligence can, provided that constructional work is not expected of him, render satisfactory services.

2. A roadway is obtained which will usually have little dust in summer and little mud in winter.

3. Partial uncovering for repairing the foundation can be easily made.

Spain. Prospero Lafarga. The porphyry used for stone block pavements is dark grey, very hard, tough, dense, waterproof and exceedingly difficult to work. The blocks of porphyry employed in Spain are roughly rectangular parallelopipedons, and are generally from 7 inches to 9½ inches long, 4 inches to 5 inches wide, and 5 inches to 6 inches deep. The upper face should be practically flat, but the other faces may be in a rougher state, provided the width of joints does not exceed one inch. Porphyry blocks are laid on a sand foundation at right angles to the line of the gutter. The side slope of the pavement should be slight, one of 1 in 200 allowing the water to run freely to the gutters. The cost of this type of paving varies from $2.67 to $5.44 per square yard.

Switzerland. Victor Wenner and Arthur Schlaepfer. Stone block pavement:—The roads in the interior of the Swiss towns have, since the olden days, been paved with cobbles. The introduction of water-supply and other pipe systems at the end of the last century, necessitating the excavation of the roads, brought about the substitution of a new and more rationally constructed pavement in place of the old cobblestone surface.

The stone pavement of the carriageway is almost

without exception laid in sand either with or without a substratum of stone, upon a well rammed or rolled foundation. When the sublayer is thoroughly drained and firm, that is, when the paving is to be laid down upon an already existing road or upon a firm stone foundation, the bed of stone is left out and the layer of sand is made 6 inches to 10 inches thick. In the construction of new roads the bed of stone is 6 inches to 8 inches thick, upon which a layer of sand and gravel of 4 inches to 6 inches is placed as the bearing foundation.

Wood block pavements:—The employment of wooden pavements has, up to the present, been comparatively small in Swiss towns, because on the one hand cheap, soft wood pavements are not sufficiently durable for our climatic conditions and on the other hand the hard wood pavements are too expensive. In addition to this the jointed layer of the wooden pavement has hygienic disadvantages in comparison with a jointless layer like that of asphalt. This is particularly the case with soft wood, in consequence of its greater capacity for the absorption of water and refuse. These defects can, to a certain extent, be effectually met by the regular tarring of the surface, which at the same time renders the soft wood layer more durable.

Brick pavement:—"Ceramite" or "Rustolith" pavement has been employed to some extent and is considered satisfactory even under heavy traffic. It consists of hard burnt tiles 8 inches by 4 inches by 3 inches, and is laid on a layer of concrete with a bed of cement mortar or sand. A final coating of liquid cement mortar covers the whole and entirely fills all joints.

CHAPTER XIII

TRACKWAYS

De Morlot, Albert, *Chief State Inspector of Public Works,* Bern, Switzerland.

Le Gavrian, P., *Engineer of Bridges and Roads,* Versailles, France.

Nessenius, Adolf, *Commissioner of Public Works, Province of Hanover,* Germany.

Sanchis, Vincent, *Engineer of Highways, Canals and Harbors,* Valencia, Spain.

France. P. Le Gavrian. Inquiries have revealed that only the Griende Department has employed trackways in paved roads. Experiments with two metalled trackways on a paved surface, with two paved trackways on a metalled surface, and with channel irons placed longitudinally, have been carried out by this department. According to the report of the chief engineer the results have not been successful.

Germany. Adolf Nessenius. Iron trackways have been constructed with very satisfactory results in different provinces since 1894. In the Province of Hanover alone, on April 1st, 1910, there were about 28 miles of trackways in use and 4 miles under construction.

Spain. Vincent Sanchis. Climatic conditions in Valencia are very unfavorable for metalled roads. Hard

stone suitable for paving is not found close by and consequently is very expensive. For these reasons a metal trackway for ordinary vehicles was constructed in 1892, which has been in constant use ever since. This was a double trackway, each rail being constructed of two bars of inverted U-shape fastened together by bolts and jointed together end to end by fish plates. The weight of rails is 152 pounds per yard. The gauge of the tracks was maintained by flat tie bars. The gauge of each track was the same as the gauge of horse drawn vehicles. The tracks were sunk 2 inches below the level of the paving, and consequently vehicles experienced some difficulty in leaving the track. Rutting beside each rail developed from this condition. Traffic over these metal trackways is conducted with great order and regularity. Loaded vehicles take to the track one after the other, both coming and going. Empty vehicles, passenger carriages and automobiles keep to the middle of the road, clear of the rails, and can go very fast without causing the annoyances so usual on busy roads, where vehicles pursue erratic courses which interfere with the general traffic and are at times a source of real danger. Where the loaded traffic is all in one direction the writer is of the opinion that a single track is sufficient. The maintenance cost for a metal trackway is very slight and traction is very easy. The wear on the track built in 1892 has been 0.0039 inches per year.

Switzerland. ALBERT DE MORLOT. Granite trackways have been constructed in several different cities of Switzerland. These trackways are each about 2 feet wide, about 1 foot thick, and are spaced about 4 feet apart on centers. The pavement which surrounds them is of a different character and smaller dimensions. The easy

running of the vehicles, the proximity of suitable materials with which to build the trackways and the small expense for maintenance justify the use of trackways. The trackways become slippery in time and in consequence have to be roughened.

CHAPTER XIV

FOOTWAYS IN TOWNS AND CITIES

HENDRICKS, C. J., *Manufacturer of Paving Bricks*, Woerden, Netherlands.

LE ROUX, NICOLAS, *Engineer of Bridges and Roads*, Angers, France.

MELLO DE MATTOS, JOSÉ, *Engineer*, Lisbon, Portugal.

ROLDAN Y PEGO, MANUEL, *Engineer*, Lisbon, Portugal.

TRUSLER, GEORGE D., A. M., C. E., *Civil Engineer*, London, England, Great Britain.

France. NICOLAS LE ROUX. The width for footways in France is generally made one-fifth of the total width of streets between property lines. For a 33 foot street the width of footway can be about 6½ feet. On streets of less width than 33 feet the proportion of one-fifth might be reduced somewhat, whereas on streets of a width greater than about 65 feet the proportion might well be increased to at least one-quarter. In very remote streets, if there is a possibility of providing for two vehicles to pass each other, this should be accomplished even if the footways have to be entirely sacrificed. If, on the other hand, the width of roadway is only sufficient for one vehicle to pass, the footways should occupy all of the width over and above that necessary for the passage of one vehicle.

The transverse slope of the footway depends upon the width and kind of surface. It should be sufficient for the

easy running off of the water, but not great enough to cause inconvenience to the pedestrians. In France the transverse slope is generally between 1 in 50 and 1 in 20, the smaller slope being used when the surface is some form of smooth paving. The different materials used for constructing the surfaces of the footways are asphalt, tile or brick paving, cement paving, granite paving and paving with small stones.

The construction of footways with asphalt is as follows: Natural asphalt is mixed with sand and laid to a thickness of about 1 inch on a cement concrete base about 4 inches thick, the top of which has been treated with a layer of cement mortar ½ of an inch to 1 inch in thickness. A thin layer of gravel is spread on the surface and gently rammed in while the asphalt is still warm.

The advantage of a tile paving is that it may be made ornamental. It is more costly than asphalt, but it may easily last 25 years, provided it is made of good material. The usual size of tiles is 5 inches to 5½ inches square and 1¼ inches to 1½ inches thick. They are usually embedded in mortar but occasionally only in sand. The joints are filled with cement by flushing the surface with rich mortar.

Cement paving presents a better appearance than does asphalt, costs less as a rule, and the hardness of its surface is generally sufficient to make it last a good while. This type of pavement consists of a layer of cement concrete about 3½ inches to 5 inches thick laid on a carefully prepared sand foundation. The concrete is covered with a coating of rich sand mortar ¾ of an inch to 1¼ inches thick. The surface of this coating is roughened with a roller and marked with grooves, giving it the appearance of a slab pavement. In spite of every care taken in the construction, and in the

choice of materials, it is very seldom that the paving does not show hair cracks which are not easy to repair. Cement paving is extensively used for footways in some towns where the materials composing it are easily procured.

The finest footways in Paris are formed of granite slabs, which may be said to last an indefinite time. The cost of this pavement varies, but is always rather high. The slabs are about 6 inches thick and are bedded in concrete. The surface is tooth axed, but wears smooth in time, although very slowly. This style of pavement is only suitable for footways on central streets with slight grades which carry a heavy foot traffic.

Stone paving has doubtless been in use from time immemorial. Footways have generally been paved with stones obtained from the cutting down of old stone blocks. These will all become very slippery and rounded so that walking over them is very troublesome. This kind of paving should not be allowed except in footways away from the center of towns where they are subjected to hard usage and where they are often used for the unloading or stacking of heavy goods.

The footways must be protected on the carriageway side by a solid curb. Too often the curb is made up of a row of headers or even of stone blocks bedded in sand and hardly let into the roadway at all. Such curbs should not be allowed. On important streets the curb should invariably be made up of dressed stone. The upper face of the curbstone should be dressed in accordance with the transverse slope of the footway. The front face where visible should have a sufficient batter to keep the vehicles from touching the top edge of the curb.

Trees can only be placed on footways which are so

wide that they do not cause inconvenience either to the traffic or to residents on the streets. They should be placed far enough away from the edge of the curb so that they may escape being hit by projections from vehicles and also so that the roots will not displace the curb. They should also be far enough from the houses so that the branches will not inconvenience the inhabitants either by depriving them of light or by injuring the walls or the roofs of their houses. Trees should therefore only be placed on footways at least 13 feet wide. Where trees are planted on paved footways an open space should be left around each tree, not only in the interest of the tree but to prevent its disturbing the pavement during its growth.

Great Britain. George D. Trusler. Under the London Building Act a common width of roadway of 40 feet is required, which provides for a carriageway 24 or 25 feet wide, the remaining 16 or 15 feet being divided up equally on each side of the carriageway for the footways.

In the case of natural and artificial flagstone footways it is customary to bed the flagstone in lime mortar on a layer of clinkers 2 or 3 inches in thickness. Footways having a surface of this kind are built with a cross-fall of 1 in 30 to 40. The writer believes that Yorkstone is very superior to any other form of flag paving. It wears well and gives satisfaction. It is extensively used by the London County Council on street widenings and improvements and is found to be more satisfactory than any other form of paving.

The most favored form of *in situ* paving for footways in the City of London is asphalt. It is found to be practically non-slippery, wears even and is easily patched. The natural rock powder compressed is used and is preferred to

the mastic where there is a continuous traffic, since it is tougher and wears very much longer, but if laid in sections not much used it wears rough and crumbles. In the main thoroughfares of the city the asphalt is laid on a 3 inch concrete foundation to a thickness of $1\frac{1}{4}$ inches when compressed. It will wear from four to five years without requiring patching and repairs. Asphalt is usually laid with a fall of from 1 in 40 to 50. The footways are flushed with water at night and squeegeed leaving them perfectly clean and sanitary.

Netherlands. C. J. Hendricks. In Holland the footways are constructed with widths varying from 6.4 feet to 12.8 feet according to the intensity of the traffic.

Footways having surfaces of asphalt, cement, or other materials set in cement have certain disadvantages, since they are apt to become slippery during rains, may crack in winter and make an impermeable covering over the subsoil. If the roadway is laid with a covering which is impermeable to water and air it is better to place the water pipes, gas pipes, etc., under the foot pavements where they can be easily accessible. Again there is danger that gas may perhaps arise from the subsoil and find its way out through adjoining houses if the footway is covered with impermeable materials. This latter disadvantage of impermeable coverings is of great importance in Holland, which lies for a great part on a morass foundation. It is a consideration of the above features and the low cost which has given rise in Holland to the general acceptance of brick as the best suited material for the paving of streets and footways.

The Rhine brick, made from clay deposits near the Rhine, is particularly suited for footways. The bricks are

about 7 inches by 3½ inches by 2 inches in size and are generally bluish in color on the outside and bluish red on the inside. Its very good appearance, low cost, retention of its rough surface even under wear, and easy removal are some of the advantages claimed for a pavement laid with this kind of brick. The bricks are laid on a well rammed sand or gravel bed, and the joints are then filled with sand. Footways constructed with Rhine bricks, laid more than 25 years ago, can be found in several of the cities in Holland.

Portugal. Manuel Roldan y Pego, and José Mello De Mattos. A system for foot pavements is used in Lisbon and other Portuguese towns which consists in laying at random small stone blocks in arcs of circles, with close joints, on a properly prepared foundation. A hard limestone and a basalt are used for this work and by means of templets the workmen are enabled to lay the stone in fancy designs, which together with the contrast brought out by the two colors of stone make a very pleasing effect to the eye. It is claimed that the rain water runs off footways built of this material without any appreciable soaking into the subsoil. In addition to their artistic appearance these sets wear very slowly and evenly, notwithstanding the great difference in quality of the two materials employed.

CHAPTER XV

ROAD MACHINERY AND TOOLS

Blanchard, Arthur H., M. Am. Soc. C. E., *Deputy Engineer, Rhode Island State Board of Public Roads,* Providence, R. I., U. S. A.

Gola, Emilio, *Engineer,* Milan, Italy.

Machnitsch, Rudolf, *Imperial Chief Engineer,* Görz, Austria.

Pelle, C. F. J., *Engineer of Bridges and Roads,* Paris, France.

Pons, Alfred, *District Inspector,* Montpellier, France.

Thomas, Edmond, *Civil Engineer,* Brussels, Belgium.

Verger, Casimir, *Assistant Engineer of Bridges and Roads,* Paris, France.

Waïcht, Ceslav, *Engineer of Highways,* Warsaw, Russia.

Wakelam, H. T., M. Inst. C. E., *County Engineer of Middlesex,* Westminster, London, England, Great Britain.

Austria. Rudolf Machnitsch. On account of the steep gradients encountered on the mountain roads of southern Austria compression is obtained either by rolling with a hand roller or by diverting the traffic to the newly constructed road. The light roller mentioned is made of concrete and weighs 882 pounds. One of these is provided

for each twelve miles of road. Each road attendant is also provided with a variety of small hand tools, such as crow-bars, drills, hammers, picks, shovels, rakes, straight-edge, water-level, etc.

Belgium. Edmond Thomas. Among the advantages of the petrol driven roller over the old types are the following: less obstruction; facility and saving in rail transport; simpler and more convenient handling, the boiler being abolished; absolute safety and therefore complete independence as regards official inspection; lessened work of maintenance; no disturbance to surface on starting.

It would appear that these light rollers comply with the new ideas regarding mechanical consolidation; namely, that the binding together of the materials must be sought in bringing about their juxtaposition by means of the rolling action and not by weight alone. With a heavy machine a portion of the work expended serves no better purpose than in crushing the metalling, more especially where only a thin new coating is spread.

France. C. F. J. Pelle. The Salmson and Contant oil driven roller was first tried out from 1903 to 1905. It is a three-wheel roller weighing from 17½ to 20 tons and is driven by an oil motor of 25 to 30 horse-power. Owing to the compactness of the engine the makers were able to bring the back wheels closer together so that the front wheel was overlapped by each back wheel about 12 inches to 14 inches. The results obtained with this roller were very satisfactory so far as the facility of working and quality of work done were concerned. The only fault that could be found with it was that the motor was not powerful enough, especially on gradients steeper than 5 per cent. As a result of some trials made with this type of oil engine and a steam

roller of the same weight on recoating work, it was found that a saving could be made in one instance in favor of the oil roller of about 23 per cent, and in other instances the cost worked out about the same for the two rollers.

The Laffly petrol driven roller is a lighter three wheel roller weighing from 5½ to 9 tons and is driven by a two cylinder gas engine, which develops between 12 and 15 horse-power. The back wheels overlap the front wheels about 6 inches on either side. The first trials with this roller were made in 1908 in Paris, where its work was compared with the work done by a 3 ton horse roller. The result was that the Laffly roller could do the work as well and in a much quicker time at a saving of about 14 per cent. In figuring the cost of work done with the Laffly roller overhead charges were included. Further trials with this roller were made in repairing isolated patches and in constructing roads with a poor subsoil for a foundation. These trials showed the roller to be particularly efficient for this kind of work.

Some of the advantages claimed for the petrol motor rollers are the following:—

1. No time is lost in waiting to get up steam and no cartage is required in supplying the roller with either fuel or water, as is the case with the steam roller.

2. The rollers are less noisy, are smokeless, and are capable of much more rapid movement.

3. They are much more compact and hence are able to work to better advantage on roads where the passage of other vehicles is of importance.

4. The lighter rollers from 6 to 8 tons in weight can be used in building roads on a bad subsoil where the use of a heavy steam roller would be impossible.

5. They are particularly useful in repairing isolated patches and on maintenance work.

France. Alfred Pons. Fault has been found with stone crushers on account of the tailings that get in with the graded sizes of the stone. The writer believes that the manufacturers of stone crushers should give their attention to the projections on the jaws so as to ensure more uniformity in the shape and size of the product.

The removal of dust is generally accomplished by means of brooms. Where the layer of dust is thick, the hand push broom is used. In order to stiffen a brush of this kind a series of rods, which encircle the brush and which can be shifted up or down, are employed. The squeegee and scraper with iron blades can be used only for removing the top layer of dust of a certain thickness without touching the surface of the road. In the open country these tools are not employed for cleaning the surface and the writer believes that a hand drawn rotary sweeper would be a much better device.

For several years past sweeping and watering have been combined in one machine. As soon as the dust has been picked up by the revolving brush it is moistened by a fine water spray which prevents its being scattered broadcast. In Germany and in Belgium sweeping machines are employed which deliver all of the sweepings carried into a chest by means of an elevator. Some have not been successful, although the principle should offer some advantages. The sweeping machines best adapted for thoroughly cleaning smooth paving are those provided with a roller brush of bamboo or fibre, to which are fitted scrapers with rubber blades, which can be raised or lowered by means of a special lever. Both simple sweeping machines and those

having a watering attachment have been fitted with motor power.

Of late years large towns have tried automobile water carts of the steam or petrol driven type. The capacity of the motor water carts does not usually exceed 790 gallons. The spray is placed near the front of the carriage so that the watering is always under the eye of the driver. Another advantage of this arrangement is that as the machine rides over the road it has just watered, it does not raise any dust.

Scarifiers have been economically used to break up the old surface of the roads. The Bobe scarifier can be drawn either by road roller or by any other tractor weighing at least 10 tons. The apparatus consists of a solid body of channel iron carried on two wheels and supporting by the axle the cast iron block holding the three steel picks, which are placed on an angle and which can be regulated so as to scarify or break up the surface to any desired depth. As the machine is borne only on two wheels, two cast iron discs are fastened on the side frames and act as counterpoises, thus ensuring equilibrium. The picks are brought in contact with the ground automatically and are similarly released. From trials made in Paris it appears that the Bobe machine can scarify 48 square yards of any solid porphyry metalling in an hour at a cost of 5.6 cents per square yard. The cost is much less with sandstone metal. In some instances the machine was able to break up 210 square yards an hour at a cost of only 2.05 cents per square yard. The Morrison scarifier is manufactured by Messrs. Aveling and Porter. Its essential parts consist of a wrought iron frame and of a block to which are fitted the picks, which by means of a lever can turn round a horizontal axis. The block can be raised vertically by means of a wheel

and thus be adjusted to any desired position. This machine can be worked either in tow of the roller or pushed by it.

Various machines of the plough type are in use for cleaning the shoulders and ditches. Most of these are drawn by animals. The blades and wheels are so arranged that the ditches can be readily cleared as the machine is drawn along the road.

France. Casimir Verger. The scarifiers of the City of Paris belong to the three following categories:—

1. Scarifiers attached direct to a steam roller, such as the Morrison type. These are not suitable for hard roadways. The scarifying is irregular and the tractor deteriorates rapidly.

2. Towed scarifiers, such as the Zettelmeyer type. This type of machine performs good work on roadways of medium hardness but it still has many imperfections as regards hard roads, where it overturns and may cause accidents in consequence of the fracture of the chain. These machines cannot be used for breaking up the roads. The long chain avoids, however, the passage of the roller over the surface already prepared.

3. Coupled scarifiers, such as the Bobe type, have given excellent results. The safety of the public is secured and the scarifying is regular. They break up the road to the depth of 1 foot in one cut, when the roadway has been well watered. The distribution of shocks, which operate on a great number of points, diminishes the deterioration of the tractor. After three years of extensive work with these scarifiers the steam rollers do not show any trace of damage. The steam roller travels each time over a certain section already scarified, but this inconvenience is not of great importance.

The first cost of scarifying with the Bobe and Zettelmeyer machine is the same. The surfaces treated per hour are about the same for both types and steam rollers of 14 to 15 tons weight suffice to draw each of them.

At Paris the preference is given to the coupled scarifiers, the scarifiers towed with a chain having been reserved for metalling of a moderate hardness.

Whatever the type of scarifier, the cost per square yard of mechanical scarifying (on an average of 2.2 cents to 2.8 cents, all charges included) is below that of hand picking (2.4 cents to 6.5 cents). In a day of eight hours 1,800 square yards can be scarified, and when the road has been moistened several days in advance it is possible to attain as high as 2,900 square yards or even more.

In comparing the work done by motor driven and horse drawn machines for cleaning and watering the writer has reached the following conclusions:—

1. The average amount of surface swept by a petrol motor driven machine at Paris varies from 14,352 to 17,940 square yards (3 to 3.7 acres) per hour. These surfaces are four times greater than those covered by horse drawn machines.

2. The average amount of surface watered with steam or petrol driven watering carts varies from 21,528 to 34,086 square yards (4.4 to 7 acres) per hour, about three times greater than the surface watered by a one horse drawn water-cart.

3. The quality of the work done is equally good with either motor driven or horse drawn machines.

4. The daily expenses per acre for sweeping or watering by motor driven machines, although below those corresponding for horse drawn machines, are still too costly on

account of the charges for sinking fund and repairs. It is possible to reduce these charges by simplifying the mechanism, and strengthening the working parts.

5. The motor driven water-cart, made exclusively for watering, has a very limited use during a few months only. This disadvantage can be avoided by attaching an easily detachable roller brush. The weight of the machine is increased by this addition only 661 pounds, which is of no importance. The apparatus, if provided with a removable tank, may be transformed into a lorry for transportation purposes.

Great Britain. H. T. Wakelam. Petrol motor driven rollers have now been in use in connection with road work for about five years. The back roller is usually 3 feet in diameter and 4 feet wide. The total weight of the smaller type is 6½ tons empty and 7½ tons loaded. Some types, however, weigh 12 tons. The consumption of petrol varies from about $^1/_3$ of a gallon an hour for the smaller types to 1¼ gallons an hour for the larger sizes. The roller is usually speeded to 1 and 3 miles an hour when the engine is running normal. It is possible to vary the engine speed above or below the normal by a hand controller. The roller is driven by chain. The wheels are generally of the same width and run tandem fashion.

The working charges for operating a 5 ton motor roller are at the rate of about 3.2 cents an hour including wages, petrol, stores and repairs which amount to about 24.4 cents per working day. This size of roller will consolidate about 3,000 square yards of tarred materials on footpaths in a working day of eight hours' duration. In rolling tarred macadam on carriageways the quantity rolled is reduced owing to the interference of other traffic, and it

also varies with the rates of the supply and quality of the materials consolidated.

Italy. Emilio Gola. A new machine to which the writer would like to call attention is the Guerrini motor hopper sweeper. At the first trials made in January, 1909, at Milan and Turin, excellent results were obtained. The machine lifted off the road all sorts of material, whether light or heavy, and deposited them directly in the hopper.

The machine and brush are driven by a 30 horse-power four cylinder motor with chain drives. Three speeds and a reverse are provided. A special device ensures a constant relative speed of the brush. The brush is 4.2 feet in diameter and is made up of twenty parts arranged lengthwise of the cylindrical surface. An arrangement is provided so that when brushes get worn down they may be set out a little in their bearings, it being possible to continue this process until practically the whole length of fibre in the brush is worn out. The cylinder to which all of these small rotary brushes are attached is set just in front of the hind wheels of the machine. It revolves under a wrought iron cover open at the bottom and provided with a rectangular opening at the top. The sweepings are picked up by the brushes and thrown by centrifugal force through the opening of the wrought iron cover into a chest which is fixed behind the rear wheels and which holds over a cubic yard. Doors are provided in the back of the chest so that the sweepings can readily be removed. The width covered by the sweeper is 5 feet. At a speed of 7.5 miles, about 21,500 square yards can be swept in an hour.

Russia. Ceslav Waïcht. The implements used in Russia for road repairs are divisible into three classes accord-

ing to the work they perform; namely, rollers, scarifiers, and mud and dust sweepers.

At the present time horse drawn rollers are used in resurfacing 75 per cent of the Empire's roads. The first steam rollers for road repairing in the Warsaw district were of the Aveling and Porter type and were imported from England in 1877. Since 1890 several works have been established in Russia at which various types of rollers are manufactured.

Mechanical scarifiers have not been much used as yet in Russia. The "Econome" scarifier designed by the writer has been used with great success for the past three years, four horses furnishing sufficient power for its successful operation. With this machine a single central blade is first set to work and with it parallel furrows are made in the old surface 12 inches to 16 inches apart, after which the two other blades are brought into use and with the three blades the whole surface to be recoated is easily scarified.

Road sweeping has been done by manual labor in Russia up to the present time, but machines have been tried out to a limited extent with very favorable results.

United States. Arthur H. Blanchard. The tar coating machine manufactured by the American Tar Company has been used in Rhode Island to mix refined tar with cold broken stone and has accomplished excellent results on work under the direction of the writer. This machine consists essentially of a long trough, with an incline at each end, equipped with a fire box and mounted on wheels. Under the middle portion of the trough three hot air pipes pass through a bath of bituminous material. The cold material is introduced in either of the jackets on the sides of the trough, which jackets form a continuation of the

compartment beneath the trough. The cold material naturally goes to the bottom of the bath while the hot bituminous material rises in the jackets and flows into the trough through holes in the inside walls of the jackets. Cold stone is placed on the incline furthest from the work and raked from there into the hot bituminous material and then onto the other incline under which there is a hot air bath, by aid of which superfluous bituminous material is drained from the coated metal. It would be advantageous if the incline on which the cold stone is first placed had a hot air jacket beneath it, in order that the stone could be slightly heated before being raked into the bituminous material. This is especially pertinent if work is to be done after the first of October and if compounds containing an asphalt, solid at ordinary temperatures, are used as binders. With refined coal tars the machine worked very satisfactorily and proved very economical in manipulation during the usual working season.

CHAPTER XVI

GARBAGE REMOVAL, CLEANING AND WATERING

BALLÓ, ALFRED, *Commissioner of Street Cleaning,* Budapest, Hungary.

BERTHET, E., *Councilor of State,* Monaco.

BRET, E., *Chief Engineer of Bridges and Roads,* Paris, France.

HÖPFNER, PAUL, *Imperial and Municipal Commissioner of Public Works,* Cassel, Germany.

KELLNER, DR. HANS, *Director of Public Works,* Brünn, Austria.

ROSHAÚW, J. C., *Director of Highways,* Christiania, Norway.

SPITERI, JOSÉ RODRIGUEZ, *Chief Engineer of Highways, Canals and Harbors,* Malaga, Spain.

YABBICOM, THOMAS H., M. Inst. C. E., *City Engineer,* Bristol, England, Great Britain.

Austria. DR. HANS KELLNER. The frequent watering of wood pavements is considered detrimental because the constant change from a wet to a dry condition causes the wood to deteriorate. Watering is considered very necessary for a macadam road because of its tendency to preserve the road in dry weather.

In cleaning the jointless surface streets and the ordinary pavements, the primitive method of sweeping with hand

brooms, the collection of the sweepings by means of shovels and wheelbarrows into heaps that are later loaded into collecting carts is employed. Specially designed sweeping plants may often be used with great advantage. These consist: (a) of light frames bearing portable cans, generally made of iron, with facilities for the carriage of everything that the workman requires (broom, shovel, scraping tools, etc.); (b) of a platform wagon upon which the cans taken from the frames can be easily and safely placed. Each plant should be provided with a sufficient number of cans so that the men sweeping will not be delayed for the lack of empty cans. The filled cans are removed on the platform wagons and empty cans are left. As soon as the wagon is fully loaded it is brought to the sweepings depot to discharge its load and then proceeds again on its rounds with the emptied vessels. This kind of cleaning, of course, requires a careful study of the local conditions and a correct distribution of the workmen, so that neither the sweeper nor the collecting wagon is idle.

Sweeping machines are being introduced more and more. Sweeping, however, is considered insufficient to remove all dust or mud, and hence it is necessary to resort to washing.

Water-carts drawn by horse or propelled by steam or gasoline are now in use, the methods of distribution of water being by means of turbine wheels, rose pipes, swinging hose pipes, etc.

France. E. Bret. The removal of house refuse is accomplished by placing garbage cans on the highway one hour before the time of collection and removing them immediately at the appointed time. A practice which should be stopped, because of the scattering about of the

refuse to some extent, is the sorting over by the poor of the garbage in the cans after they have been placed on the highway. Sweeping should be done, as is not always the case, after the collection of the garbage.

In the majority of towns the sweeping of foot pavements is left to the householder. As these latter are particularly interested in the cleanliness of the foot pavement, this method of procedure has usually no disadvantages, except that in wet weather if the pavements are not swept they become muddy. In Paris the sweeping of the footways is done by the municipal workmen and workwomen commencing at 4:00 A. M., so as not to disturb the foot traffic and to reduce the dust nuisance. When necessary, the mud scraping of the footways is carried out in the day time. In certain towns, for instance Orléans, the house proprietors have the choice between carrying out the work themselves and paying a tax.

Sweeping is considered insufficient to entirely remedy the evils of dust and mud, and hence the washing of pavements and mud scraping are common in connection with sweeping. Some of the wood pavements of Paris are washed daily. Usually the washing consists of an ample watering at two separate intervals, allowing the water time to act, followed by a sweeping if the pavement is stone block, or by squeegeeing with a rubber squeegee, if the pavement is asphalt or wood. The quantity of water required varies from 0.11 of a gallon to 0.22 of a gallon per square yard for asphalt, 0.22 to 0.44 of a gallon for wood, and increasing to 0.44 to 0.66 of a gallon for stone pavement. Hose washing gives the best results, but can be used only in towns with an abundant water supply. Rain is usually depended upon to wash sidewalks, but

in dry weather resort is made to washing them by artificial means.

In many places the piles of sweepings are made at the side of the street or in the gutters and are either removed in dust wagons or flushed into the sewers. The gutters in some cities are flushed twice a day to remove products of road sweeping or dirty water from the houses. The flushing of gutters is often left to the proprietors who do it by opening hydrants, but this method lacks concerted action.

Watering is done to prevent dust rising, but care should be taken that this is not done to excess.

At Paris, the number of daily waterings are usually distributed thus:

April, May, Sept., Oct.		2 waterings on the main thoroughfares.
		1 watering on the secondary streets.
June, July and Aug.	Pavements	3 waterings on the main thoroughfares.
	"	2 waterings on the secondary streets.
	Macadam	3 to 4 waterings on the main thoroughfares.
	"	2 to 3 waterings on the secondary streets.

It is occasionally necessary to apply water in March and November.

The minimum amount of water to be daily used per square yard can be estimated as follows:

	Spring and Autumn	Summer
Macadamized roads	0.20 of a gallon	0.40 of a gallon per square yard.
Wood block pavements	0.02 " "	0.22 " " " "
Stone block pavements	0.09 " "	0.18 " " " "
Asphalt pavements	0.07 " "	0.13 " " " "

Germany. PAUL HÖPFNER. Sewers are seldom made use of for carrying away the sweepings because of the large quantities of water required and the unquestionable fact

that it is cheaper to cart sweepings away rather than lead them to drains and later before they reach the natural stream to have to remove them.

Where the main part of the work is done by night, sweepings necessarily taken up during the day are placed in bins on footways and carted off at night in connection with the regular work. The wagons used are not covered because the materials are dampened and therefore are not dusty.

Machines which dampen, sweep, and take up material have been used but have not proved satisfactory. It is considered better as far as the results secured are concerned to use water-carts followed later by horse drawn or hand sweepers. The period lapsing between the watering and the sweeping should be governed by the condition of the weather. Washing machines consisting of a watering tank equipped with rubber rollers to drive the wet mud into the gutters are used. Footways are first wet by hand carts or cans and then cleared by hand with piassava or rubber brooms. Automobile water-carts are rare as are also tramway watering tanks. The water-cart is usually horse drawn or more rarely hand drawn.

The sweepings are used quite extensively by farmers for fertilizer and hence it is desirable to have the house refuse and street sweepings carried off separately. Where the demand for sweepings for fertilizing purposes is not so great, use is made of them for grading purposes about the city.

Great Britain. THOMAS H. YABBICOM. In sixteen large towns making reports it was found that 60 per cent of the roads are macadam, 32 per cent stone block pavement, 3 per cent wood block pavement, and 5 per cent constructed of various materials including asphalt. From

the above percentages it is evident that the cleaning of macadam roads is of the greatest importance in England.

Reports from twenty towns showed that horse drawn sweepers are used in fourteen, while in the remaining six the engineers consider that they damage the road surface. Machines to sweep and load in one operation have been used, but they are not considered practicable. Attempts to combine watering and sweeping in one machine have not proved satisfactory, the general practice being for the water-cart to precede the sweepers. Main streets are swept daily and secondary streets are swept three times a week. In most cases sweepers are kept constantly at work, the sweepings being placed in bins which are either above or below the surface of the pavement. Later these bins are emptied into wagons, the material being carted away and either dumped into the rivers or sold or given to farmers for fertilizers.

The water used for watering streets is paid for by volume, by lump sum per year, or it is obtained free. In all but two towns the water-carts are horse drawn. At present there is a tendency to replace the water barrels on the carts by rectangular tanks. The general practice now is to use tanks giving a small flow or spray. It is believed that continuous watering decomposes macadam.

Hungary. Alfred Balló. In Budapest the city cleans the roads, and the property owners the sidewalks. The cleaning is done almost entirely by hand, each sweeper having to take care of an area of about 6,207 square yards on an average. The sweepings are collected in cars and taken to stations where carts are in readiness to take the material away. The transfer to the carts has of late been done in a closed room to prevent the spreading of the dust.

There is in this room also a reinforced concrete tank, capable of being hermetically closed, into which any surplus sweepings are placed.

The dust carts are built of iron, each with a bin holding 6½ cubic yards. They carry the sweepings to a railway station situated outside the inhabited part of the town and built expressly for this purpose. Here a large electric traveling crane lifts the full dust cart bins from the trucks without touching their contents, and exchanges them for empty ones. The full bins are then placed by this crane onto the railway cars, on which they are brought to the refuse factory to be emptied. Here the sweepings from the streets are combined with fecal substances and sold as manure for agricultural purposes.

Asphalt streets are washed in summer to some extent by hand or machine. The machines used are water-carts equipped with rollers or some other device to displace the mud.

Although owners are supposed to keep sidewalks clean, boys from twelve to sixteen years of age are employed to collect large articles of waste from the sidewalks.

About one-fourth of the street area is watered from hydrants and the remainder by water-carts. The water-carts are mostly of the old perforated tube type, but are being replaced more and more by those of the valve cylinder type.

Monaco. E. Berthet. In Monaco the street cleaning is done entirely by hand and with great thoroughness. Household refuse is carried away in carts between six and eight o'clock in the morning and the material is burned in a destructor of the Horsfall type. These carts are washed and disinfected daily. Dust and horse dung is removed by portable scoop shovels and carried to bins which are built on the sidewalk and covered with foliage or beneath the

surface of the pavement, or it is placed in portable cans. The wagons collect the sweepings from the various receptacles when they pass. The bins and cans are regularly disinfected. Chloride of lime is spread over the bins during the heat of the day in summer.

The mud is collected by a scraper and the liquid mud is collected by means of a scoop, an operation which rarely has to be performed at Monaco. When a slight rain occurs, a thorough road washing generally insures a sufficient cleansing. All road sweepings are deposited at the public depots and covered up with rubbish, thus preventing all emanations.

Besides the corps of sweepers who are engaged in fixed duties, there is a flying column controlled by an overseer. The functions of the flying column are: the care of the torrent beds, ponds and lavatories; the removal of seaweed blown on the shore; the cleaning of the foreshore and beach; the disinfection of certain localities, corners, blind alleys, etc. One man is specially in charge of the cleaning of lavatories and two men are attached to the French Department of Bridges and Roads in order to insure the cleanliness of the National Highway, Number 7, on the immediate frontier of the Principality.

Watering is done by means of hose pipe, because such apparatus is considered less cumbersome than a water-cart.

The 239,200 square yards of surface swept and cleaned costs $2,702 per annum, not including the cost of the water.

At certain places the night dampness renders the road slippery. This defect is remedied in winter by spreading clean, fine sea sand over the road at such places as may require it. This sand is stored in bins under the foot pavement or concealed in some other way.

Norway. J. C. Roshaúw. In Christiania ordinary sweeping is accomplished by horse sweepers and by hand, although the former method has proved to be more satisfactory. Combined sweepers and sprinklers are not practicable because they are too heavy for the steep grades encountered. Macadam roads are scraped in wet weather. Streets are watered immediately before sweeping by means of water-carts with turbine or tube distributors. The latter type is preferred. Ordinary sweepings are usually taken out in the bays and dumped, while sweepings from paved streets are employed for fertilizer.

Besides the ordinary sweeping of roads, which is carried out under normal conditions, in accordance with the traffic of the streets, from one to six times a week, workmen are continually employed in the main streets to collect the horse droppings, in order that the streets may always present a clean appearance. These workmen are supplied with a light wheelbarrow, the contents of which they empty into small galvanized iron bins, provided with covers, and placed at convenient distances along the street. These bins are emptied into the receiving carts. The contents thus collected are transported elsewhere, and finally are sold to the gardeners and peasants at a profit.

Spain. José Rodriguez Spiteri. The soil absorbs the germs of all infectious diseases of both human beings and animals and in the densely populated cities it contains a greater number of them than in the country districts. Fraenkel has found that the soil of Berlin contains 450,000 germs per cubic centimeter; according to Miquel the mud of Paris streets contains 1,000 millions of them and that of Montsouris Park only 10 millions; while Maggiora has found 32 millions in the soil of Turin.

Cleansing and watering are both largely done by hand, this method being the only one applicable to narrow, tortuous streets. The work should be done after midnight so that traffic will be interfered with as little as possible. The horse droppings and litter of various sorts must, however, be removed during the day.

In hot countries a pressure tank which sends forth a fine spray is very desirable because of the great saving in the amount of water used. Where such installations do not exist, one has to be content with ordinary hydrants and with public fountains which have to be fitted with some special arrangement for filling the water-carts. In harbors and seaside towns sea-water is used. It is drawn up by portable pumps and sometimes even by hand with buckets. It is needless to remark that where such conditions prevail, and unfortunately such instances are still very numerous, the work of street watering is done slowly and inefficiently. This is to be regretted both from a sanitary point of view and from the interest of the public comfort, both of which demand thorough work. The cost, under these conditions, is excessive.

The writer has designed a horse drawn cylindrical tank of about 211 gallons capacity on wheels, which is fitted with a very simple device by means of which the tank, when empty, can be filled in five minutes. By means of a pump, worked by the cart wheels, either a vacuum or a compression can be obtained, the former to be used in filling the tank and the latter to force the water out of the tank onto the road in a very fine spray. The writer expects that very good results will be obtained with this water-cart although he has not yet been able to try it out in actual practice.

CHAPTER XVII

REMOVAL OF SNOW AND ICE

BRET, E., *Chief Engineer of Bridges and Roads*, Paris, France.

CINQUE, VICTOR, *Chief Engineer, Province of Brescia*, Italy.

COURTOIS, AUGUSTE, *Principal Inspector of Bridges and Roads*, Bastogne, Belgium.

HÖPFNER, PAUL, *Imperial and Municipal Commissioner of Public Works*, Cassel, Germany.

MAZEROLLE, L., *Engineer of Bridges and Roads*, Paris, France.

MIKHAÏLOFF, PAUL, *Engineer of Highways*, St. Petersburg, Russia.

ROSHAŬW, J. C., *Director of Highways*, Christiania, Norway.

SPÄNGLER, LUDWIG, *Municipal Director of Streets*, Vienna, Austria.

WILHELM, IVAN, *Chief Engineer of Bridges and Roads*, Gap, France.

YABBICOM, THOMAS H., *City Engineer*, Bristol, England, Great Britain.

Austria. LUDWIG SPÄNGLER. In the city of Vienna the snow is cleared by the tramway companies which are at the present time all owned by the municipality. When the cars were drawn by horses it was a very easy matter to

clear the snow by means of horse drawn plows. With the advent of electric traction, the procuring of sufficient horses to draw the plows was attended with so much delay that the city authorities turned their attention to the use of snow-plows driven by the cars.

In general the method employed in the removal of the snow from the streets in Vienna is as follows:

1. The removal of the snow from the track by means of snow-plows driven by horses or by tramcars.

2. The shovelling of the snow into heaps along the edges of the footways by hand.

3. The removal of the snow, thus collected, by carts.

Wherever the car tracks lie in the middle of the road the whole roadway is cleared of snow in the following manner. Two snow-plows are coupled to the car and are drawn along the roadway to one side of the track. The plows are platforms mounted on four wheels and underneath the platforms are a series of horizontal rods to which are attached vertical blades or shovels, capable of being raised or lowered. When the plows are used in pairs one is drawn along to one side and just behind the other in such a way as to clear two widths at one passage. These plows can be run at a speed of about 7 miles per hour. The car itself is fitted with a series of blades which clears the snow from the track at the same time the roadway is being cleared by the two auxiliary plows. The snow is removed in this manner from half of the road by one passage of the car and plows, after which it is removed from the roadside by wagons. The other half of the road is cleared in a similar manner.

The method just described is suitable, however, only for a comparatively small depth of snow. With greater depths not only would the work be increased to such an

extent that the ordinary tramcar would not be sufficiently powerful to pull the snow-plows through the snow, but the snow would accumulate underneath the car and runners as well as under the auxiliary plows, making effective working of the plows impossible. If the fall of snow occurs suddenly there is a danger that it will become impossible to pull a snow-plow through. In such a case the blades must first be raised a few inches above the ground so that only the upper layer of snow is at first removed, the rest being dealt with on a second journey. The most important point, however, is always to get the snow-plows to work as quickly as possible.

For districts in which the snow falls rapidly in enormous quantities, the snow-plows described are not sufficient and resort has to be made to apparatus of the kind used on the railways consisting of high plow shaped inclined planes which are generally fitted to special cars that bore their way into the snow throwing it off the track to one or both sides. In this case the snow must be removed from the roadway by other means.

For clearing the track of snow alone, especially in outlying districts, rotary brushes are attached in front and at the rear of a specially designed car. The result obtained is very good, the snow being cut away and thrown to the side of the road, but for a very deep snow this machine cannot be used.

Simultaneously with the clearing of the track and the roadway the rail grooves must be cleared. For this purpose a specially designed machine called a rail scratcher is used in Vienna. It is an iron frame bearing two suitably designed castings which fit into the rail grooves and cleans them as it is pushed along in front of the car.

For the roads that are not traversed by tram lines, the snow removal operations are not managed from a central point, but are divided into districts. Apart from the fact that the operations of snow removal do not have to be started as early in the day, the methods employed are similar to those used by the tramway companies, the same style of plow is used and is generally followed by a rotary sweeper.

Due to the fact that the banks of snow thrown up by the snow-plows must be shovelled into heaps and removed as soon as possible, it is very important that the necessary supply of workmen be available soon after the snow begins to fall. For this reason it is necessary to carefully plan out the organization early in the season so that the work may be carried on without any unnecessary delays.

Belgium. AUGUSTE COURTOIS. Although the use of snow fences would keep the snow out of shallow cuts, such an expediency is not practical in road work through populated places, due not only to the objections on the part of the roadside inhabitants but also to the great cost of the fences. It is seldom that the snow lies in a layer of uniform thickness, and it is only after a long and constant fall that it attains a regular thickness of 10 inches. Such a depth of snow makes traffic almost impossible. It should be cleared away when it reaches a thickness of 4 inches to 5 inches. For this purpose a snow-plow is brought into use or the snow is shovelled off. When drawn by four good horses snow-plows cannot clear away continuous layers of snow over 10 inches to 12 inches deep, but they will negotiate banks several feet in width of even twice that depth. When the layer of snow is as thick as or thicker than 2 feet to 2½ feet shovels have to be used.

The snow-plow employed in the Luxemburg district consists of two side pieces hinged together and kept apart at variable distances by removable cross pieces, forming a triangle. The plow should be set to work as soon as the layer of snow has attained a depth of 4 inches and the number of machines used should be such that none of them has to deal with more than about 6 miles.

France. E. Bret. On account of the heavy expense which the removal of snow demands, it is left on the roads in many towns until it disappears of its own accord. Such a primitive practice is irreconcilable considering the requirements of traffic.

The method of removing snow from streets is generally to clean out a path wide enough for the travel, heaping the snow up at both sides, the work being done by plows or sweepers, depending upon the temperature of the air and the amount of snowfall. The snow is then carted away to the rivers or sewers. Snow-plows of the common triangular design, of the simple inclined board design, and of the sectional design capable of following irregular surfaces are in common use. In some cities the snow is flushed directly into gutters by water and hence to the sewers. Salt is used to melt the snow quite extensively and is usually considered practicable. It is considered the best practice to spread it before the snow is trampled down. The process leaves only mud, which may readily be removed. In Lille a mixture of one part salt and three parts sand is used which prevents slipperiness. Some municipalities are opposed to the use of salt, on account of the icy mud formed, and the effects on shoe leather and the horses' hoofs. However, these disadvantages can be minimized by sweeping the streets as soon as it is possible. Salt cannot be used, however, on

macadamized roads as it causes disintegration. The same reservation must also be made as regards foot pavements with trees, on account of its harmful action on the roots. Steam and hot water have been employed to melt snow, but both of these methods are considered too expensive.

France. L. Mazerolle. The various methods of snow removal may be subdivided into two particular classes, removal in forms of heaps or banks and thawing in place. In the first method it is necessary to provide for the removal of the heaps which have been formed with much labor, whereas in the second the water rising from the thawing is naturally directed towards the sewers.

At present in the City of Paris the work of snow removal is accomplished as follows: As soon as the snowfall occurs, workmen of the administration commence at once to salt the roadways. The salt begins to produce a thawing action only after the traffic has mixed it with the snow. While waiting for this effect to be produced, the workmen are employed in opening up footways for the pedestrians at the road crossings, while the abutting property owners clear the foot pavements as well as the gutters. The sweeping machines are then brought into use which sweep some of the liquidated mixture of snow and salt to the gutters. The flushing nozzles are then used and the heavy accumulated snow is flushed to the sewers, for which purpose the flushing water serves as the vehicle. When the thermometer remains in the neighborhood of zero, or above, the operation thus conducted is extremely rapid, but if, on the contrary, the thermometer remains somewhat below zero, the sweeping of the snow is more difficult and the flushing to the sewers is prevented for fear of ice forming. Under the latter conditions the snow is removed from the roadway

to banks at the side. Afterwards it may be carried away or melted. In Paris rock salt is used, selected mainly from the standpoint of its low cost. For a snowfall of about 1 inch about 0.18 of a pound of salt is used per square yard. The specification for the salt is as follows: the largest diameter of the grains of salt must not exceed 0.12 of an inch; the proportion of fine grains passing a sieve number 25 shall not exceed 40 per cent; the salt shall not be adulterated. The salt is usually spread by throwing from a shovel. Various salting machines, consisting of a hopper from which the salt escapes and falls on horizontal revolving blades which throw it over a roadway surface of a width of 12 to 15 feet, have been designed. The principal objection to these machines is that putting the machine to work always requires such long delays that it is by no means certain that the loss of time will be regained later.

The use of machine sweepers gives fair results in the case of snowfalls from ½ an inch to 1 inch in thickness. A great deal of trouble has been experienced in using rotary sweepers in having the bristles get choked up with the snow so that no sweeping action is performed. Powerful machine sweepers running on the rails of the tramway companies, the brushes of which are operated by motor power, have given very good results. Whatever machines may be employed, their action is the most efficacious when the snow has not been touched by the traffic. It would seem that the ideal plant for the removal of snow would consist of motor vehicles fitted in front either with scrapers or roller brushes rotating at high speed. The removal of the snow which has been swept into heaps or banks at the sides of the streets requires a large amount of work. Although it is possible to use carts, trains of small cars running on rails of tram-

ways or by means of Decauville tracks, or motor lorries to carry the snow to certain discharge depots, it is clear that the cost is considerable. Where the sewers are of sufficient cross-section, the snow may be discharged directly into them, but precautions should be taken against blocking the sewers.

It has been proposed to melt the heaps by steam jets, electric heaters or boilers, but as yet no practical apparatus has been designed for this purpose.

The organization of the service for the removal of the snow should be prepared in advance, and all the measures to be taken should be provided for in the plan of mobilization, taking into consideration the various local circumstances.

France. Ivan Wilhelm. In some parts of France, more especially in the mountainous regions, frequent heavy falls of snow occur which necessitate more or less work in the way of removal to make the roads passable for traffic. The means employed vary according to the climate and the altitude. In regions where the climate is not very severe, traffic is maintained in the winter time by passing a V-shaped snow-plow over the road occasionally. The plows are started whenever the snow reaches a thickness of from 6 inches to 10 inches. In high altitudes, if the layer of snow is thick, other measures have to be taken. The passage of vehicles must first be provided for by clearing passing places with shovels.

The employment of snow-plows is only possible up to a certain height, this altitude in the Alps varies from 3,600 feet to 4,800 feet. To keep the road open for traffic in these places a track is made by tramping down the snow with four to six horses travelling abreast after which the track

is widened with shovels. The methods described above are carried out by gangs of workmen who are recruited in the neighboring villages and are under the direction of a road foreman.

Germany. PAUL HÖPFNER. Snow is removed by collecting it into piles by the use of snow-plows and later carting it off to some suitable place to melt or to dump it into the rivers or sewers. No detrimental results ensue from dumping snow into the sewers, provided there is a large flow of water and if care is taken not to throw in too large lumps.

Great Britain. THOMAS H. YABBICOM. Snow is dumped into rivers or run through the sewers. Salt is used to some extent, but the practice is considered injurious to both man and beast, because of the intense cold produced.

Some towns have local Acts of Parliament which require the householders to clear the snow from off the footways in front of their premises. But even in these towns there are many miles of footways in front of unoccupied premises, public buildings, places of worship, bank walls, on bridges and viaducts where the paths would never be cleared at all unless it was done by the municipality. In some towns the authorities undertake the whole duty. The snow, when cleared from the path, is placed in the road, and then is removed at the public expense.

Italy. VICTOR CINQUE. On the ordinary roads in Italy a permanent staff sweeps the snow into heaps along the sides of the road when the depth does not exceed 1¼ inches to 1½ inches. In the towns, when the bed of snow is relatively thin, the snow is removed by flushing it with water into conduits placed expressly for this purpose along the streets. When the depth of the snow exceeds 2½ inches,

the method ordinarily used consists of sweeping by machines. The machine most commonly employed for the removal of snow on ordinary roads is a V-shaped snow-plow carrying a weight which varies with the depth of snow to be removed. The snow-plow is drawn either by horses or by oxen.

As regards the cost of removing the snow, it varies according to the system used. In certain towns as soon as the total surface of the roadway under consideration has been determined, the price, graduated for each inch of thickness of snow for sweeping and transportation to depots, is determined by contract. In other towns a special price is given for each cubic yard of snow swept and heaped along the road and a separate price for the transportation to the public depot.

On ordinary roads used by tramways a snow-plow is employed on that part of the road used by ordinary vehicles. Afterwards the removal is completed by sweepers and the road at its most important points is entirely freed from snow.

Machines which have been designed for the purpose of thawing the snow have had, as yet, no appreciable success, although numerous experiments have been made.

Norway. J. C. Roshaúw. At Christiania the treatment of snow includes not only its removal from the street, but also the maintenance and repair of the roads used by sledges. The work consists in maintaining the roadways in an efficient state for sledge traffic as long as these vehicles are being used in the environs of the town, which usually means several months during the winter. During this time only the paved and asphalted footways are cleared of ice and snow. A layer of snow is left on the gravel footways and is sometimes maintained at a uniform thickness by means of snow-plows or scrapers. The snow layer is

kept about 6 inches in depth except in the gutters, which are kept open. In the spring the snow is broken up and carted away, as is also the excess snow during the winter. Sanding is employed upon the roads only when sledges cannot be used. The sidewalks, however, are sanded regularly.

Russia. PAUL MIKHAÏLOFF. The severity of the climate and the protracted winter in Russia are such that the entire removal of snow is never attempted. All that is done is to level the coating of snow in the street and so prepare it for convenient sleighing. The levelling is so carried out that a smooth but not too thick bed is retained. Powdered snow which is heaped up by the snow-plow or scraper is cleared away and smoothed down by a snow-plow drawn by four or eight horses, before the snow has had time to settle or to become hard through the action of the traffic. A common V-shaped type plow is used which can clear a layer of snow 6 inches to 1 foot deep for a length of 9 to 12 miles per day. The inequalities in the road surface due to traffic such as slopes, ruts and pot holes cannot be removed by the plow but have to be cleared away by manual labor with picks and shovels. For this same purpose a specially designed harrow is sometimes used which consists of a triangular platform mounted on a sledge and capable of being raised or lowered by suitably arranged screws. Steel teeth are fixed to the sides of the platform which cut out the humps of snow as the harrow is drawn along. Consequently the height of the platform must be adjusted to the height of these humps.

In some cases where large drifts have formed, it is impossible to clear them away even by hand until after the snow has ceased falling and hence traffic is sometimes stopped for a while. The direction in which the road runs,

the direction in which the wind blows, whether or not the road is in a cut or on an embankment, the depth of the cuts and embankments are all factors which influence the method of operation. At such places on the road where deep layers of snow are formed, snow fences should be erected. On roads fir branches are employed as a substitute for the specially constructed and expensive snow fences. With the first snowfall at the beginning of winter the snow is heaped up into mounds wherever protection is needed. These mounds are about 6 feet in width and are placed at a distance of about 60 to 90 feet from the road. On top of these mounds are fixed branches of fir trees, about 3 to 6 feet high, so as to form a continuous screen. When the snow gets over the top of these branches they are drawn out of the snow, other mounds are raised with the snow itself and the branches are again fixed on the top. This operation is repeated as many times during the winter as may be found necessary.

CHAPTER XVIII

ROAD SIGNS

BRADACZEK, THEODOR, *Imperial Commissioner of Public Works,* Prague, Austria.

COLARD, H., *Delegate of the Touring Club of Belgium,* Brussels, Belgium.

CHAIX, EDMOND, *President, Touring Committee, Automobile Club of France,* Paris, France.

FOURMANOIS, A., *Delegate of the Touring Club of Belgium,* Brussels, Belgium.

NAVAZZA, AUGUSTE, *Director, Touring Club of Switzerland,* Geneva, Switzerland.

NÉMETHY, JOSEF, *Royal Chief Engineer,* Zilah, Hungary.

POS, G. A., *Vice-President, Touring Club of Netherlands,* Baarn, Netherlands.

TOLLER, GINO, *Engineer,* Milan, Italy.

VAN MEERBEECK, H., *Delegate of the Touring Club of Belgium,* Brussels, Belgium.

VAN ZEEBROECK, ED., *Delegate of the Touring Club of Belgium,* Brussels, Belgium.

Austria. THEODOR BRADACZEK. The road signs erected at each cross road in the Kingdom of Bohemia are very substantial and give very complete information in regard to the distance and the direction to take. These sign posts

are constructed on the spot either of stone or of concrete. The post is square in shape and about 5 feet in height. On each face near the top and parallel to the road in question are given the names and the distances with arrow pointers to the terminal cities which the road connects and below are given the names and distances to the intermediate towns which must be passed through. As a further aid to the traveller a color scheme has been adopted by which directions are indicated by colors. For instance, roads running from east to west are marked in red or brown colors, those from north to south in blue, those from northwest to southeast in green or violet, and those from northeast to southwest in yellow. On the faces of the monuments above described a small rectangle of the appropriate color is painted. This same color scheme is further carried out in marking the milestones on the road with the result that it is very easy for a stranger to find his way. The writer recommends that the road maps have the roads to different points shown in colors that correspond to those placed on the milestones and road sign posts.

Belgium. Ed. Van Zeebroeck, H. Colard, A. Fourmanois and H. Van Meerbeeck. It is believed that the desired warning for all dangerous points can be given by means of one sign bearing for a symbol, for instance, a triangle to mean reduced speed. Such a sign would concern everybody and obedience to such an injunction would tend to safeguard all people on the road against dangers. The use of a number of signs, which indicate the specific nature of the obstacle and which are recommended in the interests of motorists alone, tends to encourage the imprudence of the drivers to the great danger of those they pass on the road.

France. Edmond Chaix. The General Council of the Department of Roads and Bridges has declared itself favorable to maintaining those signs which have been erected under the auspices of the Touring Club.

At a meeting at which a large majority of the automobile clubs of the continent were represented it was resolved to adopt the following danger signs which, with the exception of the third, are those recommended by the First Congress. These signs are four in number and indicate the following dangers and obstacles:

1. Turnings.
2. Obstacles along the road such as ditches, humps, bridges, etc.
3. Barriers, road crossings or railroad crossings when protected by barriers, except where such crossings should be classed as dangerous crossings.
4. Dangerous crossings, road crossings or railroad crossings when not protected by barriers.

It was thought that the round form is best except in places where railways following the roads have a similar shaped sign for their signals, in which case the sign should be made rectangular in order to avoid confusion. A diameter of about 27 inches for the sign was adopted and the colors chosen were white for the inscription and dark blue for the background. It was felt by some that the symbolic sign is sufficient to describe the danger, but others thought that the sign should be further supplemented by an explanation of the danger in the language of the country where the sign is erected. The signs are placed 820 feet in front of the obstacle to be pointed out and on the side of the road corresponding to the direction of traffic.

Hungary. Josef Némethy. In Hungary the dimen-

sions and inscriptions of the kilometre and hectometre stones have been fixed by the government. These stones are of ashlar and are marked only with figures indicating distances. There is sufficient room to mark these stones with all the information useful to the tourist, such as distances to different towns, danger signals, etc. The writer therefore believes that the following system might well be adopted.

The kilometre and hectometre stones, which serve for the marking of distances along the roads, should, without waiting for an international agreement relating to uniform signs, be altered in such a manner as to give the directions and distances of the best known towns which lie along the route. Danger signals, heights above sea level and information with respect to telegraph and telephone stations should also be inscribed on the posts. The posts should be painted white and have their inscriptions marked on them in black, except the danger signals, which should be given in red.

Road direction signs should be made use of only at branching points, road crossings and at the beginnings and ends of townships. These boards could be attached to posts set in concrete bases. The inscriptions might be printed in black letters on a white or on a light blue background.

Danger boards should be of four types indicating the following:

1. Turnings.
2. Obstacles along the road such as ditches.
3. Level crossings.
4. Dangerous crossings, railroads, etc.

If the kilometre stones, however, are provided with the same inscriptions as used for the danger boards, the latter are more or less superfluous and only needed in places where

it is desirable to give frequent warnings to travellers or where, on account of the high speed of the motor cars, the legibility of the inscriptions could not be depended upon.

Italy. GINO TOLLER. The Touring Club of Italy has had a regular and active organization for the erection of road signs and signals since 1902. Under its direction about 7,000 signs of different kinds have been erected throughout Italy.

The signal posts of the Touring Club may be divided into three classes:

1st. Direction signals, or sign posts.

2nd. Danger signals.

3rd. Special signals.

Every signal is made up of an iron pillar painted in the national colors and of a plate on which is given information of value to the travelling public. The plate can be fixed to walls, etc., should the occasion arise. The plate is rectangular and of varnished iron, the sign and inscriptions being in white on a dark blue ground. On every post are the words "Touring Club Italiano" and a number for identification.

Netherlands. G. A. POS. Since the meeting held on December 1st, 1908, both the Automobile Club and the Dutch Touring Club, although in favor of a single sign post, have placed in position a great number of posts bearing the signals adopted by the First Congress.

At crossings of light railways, which are laid down on their own right of way, "level crossing" signs are put up. For tramway crossings where the track, as often happens in Holland, crosses from one side to the other of the road, the "dangerous crossing" sign is used. The writer believes that the signals for turns, dangerous crossings, and obstacles

along the road are satisfactory in the majority of cases as regards traffic requirements; that the level crossing signal is suitable for main line crossings but neither this sign nor the one for dangerous crossings is adapted for warnings at the crossings of light railways or suburban lines; that the absence of any warning signal at descents is to be regretted.

Switzerland. AUGUSTE NAVAZZA. In Switzerland we were forced to take into account the necessity of having conventional signs due to the development of the foreign motor car traffic. In 1909 nearly 7,000 foreign motor cars entered Switzerland under a temporary permit for the purpose of touring the country. Under such conditions the writer believes it is much better to use a single sign to signify "slacken speed" as a warning for all points of danger no matter what their character may be. Such signals should be placed within 600 to 750 feet of the points of danger.

CHAPTER XIX

PIPE SYSTEMS IN ROADS AND STREETS

De Heem, Paul, *Engineer of Bridges and Roads*, Antwerp, Belgium.

Hentrich, Hubert, *Commissioner of Public Works*, Crefeld, Germany.

Jász, Didier, *Technical Councilor*, Budapest, Hungary.

Lemeunier, Richard, *Chief Engineer of Bridges and Roads*, Antwerp, Belgium.

Lidy, Georges, *Chief Engineer of Bridges and Roads*, Bordeaux, France.

Mihályfi, Joseph, *Technical Councilor*. Budapest, Hungary.

Peters, Fritz, *Commissioner of Public Works*, Magdeburg, Germany.

Silcock, Edward John, *Past President of the Society of Engineers*, Westminster, London, England, Great Britain.

Steuernagel, Karl, *Commissioner of Public Works*, Cologne, Germany.

Tur, Paul, *Chief Engineer of Bridges and Roads*, Paris, France.

Von Montigny, *Commissioner of Public Works*, Aix-la-Chapelle, Germany.

Von Scholtz, A., *Commissioner of Public Works*, Breslau, Germany.

Belgium. RICHARD LEMEUNIER and PAUL DE HEEM. A commission on which are representatives from the various departments in charge of the roads, sewers, water-supply, gas, lighting, telephone and the tramway companies could group together as far as practicable the various works to be carried out by these companies and so minimize the number of disturbances to the road. To make such a scheme successful the work should be planned so that all of the different operations will be finished at about the same time.

From a study of existing conditions in the city of Antwerp, it was concluded that pipe galleries could not be generally adopted.

In the city of Brussels in 1908 a subway was constructed as an experiment for the water pipes and the electric cables. The gas pipes were purposely excluded because of the danger of the gas main and the electric cables being in the same gallery. The subways were built of reinforced concrete and cost about $4.12 per linear foot. The experiment is of such recent date that one is not yet entitled to express an opinion concerning it.

The solution which seems to offer the most advantages or at least to offer the fewest objections is to have separate gas and water pipe lines and cables on both sides in every street and to place them under the sidewalks wherever possible. The arrangement of the pipe lines used in one of the streets of Antwerp is as follows: water main, 1.6 feet in from the curb; gas main, 4 feet; cables, 5.6 feet. The depths at which the different pipes are laid are 3.3 feet, 2.6 feet, and 2 feet respectively.

France. GEORGES LIDY. It is evident that by reason of their variety, works connected with reopening roads and streets cannot be subjected to detailed and unchangeable

rules. Too great a subdivision of services or departments connected with roads may lead to unnecessary work prejudicial to the constant maintenance of a good road surface. It is also necessary that all the departments should be in constant touch with one another and that their individual work be constantly subordinated to some understanding whereby the unavoidable obstruction caused by their works may be reduced to a minimum. The disturbances to the road cannot be overcome in urgent and unforeseen cases, but attempts should be made to minimize them as much as possible. As to works which can be carried out *ad libitum,* it is recommended that they should not be commenced until a program has been carefully decided upon by which the various works may be carried out in turn with as little interference as possible with public convenience and traffic.

The sewer is usually located in the middle of the street. In the older sewers and in the newer ones that are too small to be entered, the manholes are placed in the roadway. For the larger sewers the tendency now is to place manholes in the sidewalks, connecting them to the sewers by a branch. Gas pipes are generally placed under the carriageway, since they are not allowed in the sewers from the standpoint of danger. The light cables are almost invariably placed under the sidewalks, and at road crossings pipes or conduits are often made obligatory so that the cable can be withdrawn without disturbing the road. As a general rule there is only one water main in each street and it is placed under the carriageway. It is only in the great cities and in some of the main thoroughfares that water pipes are found under each sidewalk.

It is desirable to place under the sidewalks all of the conduits such as those for gas, electricity and water. Where

water pipes, etc., must be necessarily placed under the carriageway, the number of fixtures should be diminished as much as possible and those should be selected which are most permanent.

There does not seem to be any advantage in shifting a single main from the carriageway to the sidewalk. The presence of a main under the carriageway is not objectionable except in so far as the repairs and alterations to the house connections are concerned. The use of two mains one on either side of the street is of great advantage, since the house connections are quite short and do not interfere with the carriageway. In old roads where a single main exists, the construction of duplicate mains, one on either side of the street, could be substituted for the old main when extensive repairs were being made.

If gas pipes are well laid with proper joints, there would be no danger from placing them in well ventilated galleries.

France. Paul Tur. The experience in Paris is that well ventilated subways can safely contain gas pipes. Unfortunately subways are seldom aerated as such ventilation is very difficult to carry out. The supervision and inspection of such services in subways cannot be compared to that in dwelling houses, in consequence of which fact danger from escapes of gas are very serious.

Germany. Fritz Peters, Karl Steuernagel, A. von Scholtz, von Montigny, Hubert Hentrich. In Dresden model arrangements have been made with respect to road engineering operations which involve the construction of gas mains, water mains, etc., so that they may be regulated for a whole year ahead and in such manner that all the administrative departments concerned may lay their plans accordingly, and that the greatest possible considera-

tion may be given to the interests of the adjacent owners and traffic.

In Berlin the arrangement of the mains is as follows. A similar arrangement is used in Breslau.

1. The pipe systems are placed in the footway only when the breadth of the latter exceeds 16.4 feet, otherwise in the carriageway.

2. The gas mains ranging up to 15 inches in diameter are placed under the footway; when larger than this they are placed in the carriageway.

3. Water mains up to 9 inches in diameter are laid in the footways when these have a width of 8 feet or more; when of greater diameter than this, or when the footways are narrower, they are placed in the carriageway.

4. The electric cables, with the distance telegraph and telephone cables are placed close to the line of the buildings, a strip of about 3½ feet to 5 feet in width being reserved for them.

The tramway cable is laid next to the curbstone, while an intermediate position between the gas and water mains or drainage pipes is allotted to the lighting cables.

With this arrangement the footway ground is utilized to the utmost, so much so that, even with a width of footway of 16.4 feet, there is no room left for the planting of trees.

For suburban roads, sewers and drains may be placed under the carriageway, since there is little likelihood of the system being disturbed if properly constructed in the first place. It is believed that there are advantages to laying the water main under the carriageway, as this would guarantee against the washing out of the building foundations, which might occur in case of a break if the main were under the footway. This arrangement would also prevent

any disturbance from a similar cause to the other services which may well be placed under the footway. A similar position is recommended for the gas main, as there is more or less leakage which might be dangerous to the occupants of the buildings if laid close to the building line, as well as injurious to trees. The use of two mains for each service, one on each side of the road, is an advantage as far as the disturbance to traffic is concerned, and is the most convenient for making connections. It can only be an advantage from a financial point of view, however, when the cost of the branches from the main to the buildings on either side is greater than the cost of the two mains. Telegraph and telephone cables might also be placed in iron pipes or conduits under the carriageway, as there is slight chance of their being disturbed.

In place of the usual form of concrete foundations for pavements, the use of concrete prisms made of 1:3:5 mixture, of a height of 7 inches, a breadth of 10 inches, and a length of 12 inches laid on the properly constructed road surface has proved eminently satisfactory. The prisms, which are set with open joints in coarse sand, can at any point be at once picked out, and, on the completion of repairs to a line of piping, etc., can be put in again.

Great Britain. Edward John Silcock. The cost of sewers, large water mains and other similar works is very considerable and, having regard to the saving of interest on and the repayment of capital expenses, it is often more economical to defer the construction of the works until they are actually required than to execute them prematurely to suit the road making program.

No doubt in an ideal state there would be no such thing as dual control and the various branches of the public

service would be under one supreme head, but under present conditions this ideal is never attained.

The use of subways would only partially prevent the disturbance of the roads, since where subways are constructed, it is usually found that one such structure must be placed in the center of the road from which the branch drains or service pipes for water, gas, etc., are led across the road to the houses. This involves the tearing up of the road every time a new service is required or an old one is repaired. The other alternative is to construct two subways, one on each side of the road under the footways, or, in cases where basements extend beyond the building line, as near the basement wall as possible, in which case the service pipe would be carried directly through the walls of basements of private premises without the necessity of opening up the surface of the road. The chief objection, however, to subways is the financial one and it is found that except in the very busiest and most important streets of large towns it is quite impracticable financially to construct a system of subways.

On country roads it is desirable, as far as possible, to select the grass shoulders, where such exist, as suitable places for pipe trenches. In many cases where there are no grass shoulders it becomes necessary to place the pipe trench upon the metalled portion of the road. Where the roads are straight and wide, there is usually no difficulty in placing the pipe on the haunch so that it shall not unduly interfere with traffic during construction or permanently through the presence of manhole or valve covers. Where sewers have to be constructed in winding roads, it is necessary to lay the pipes in straight lines, which involves the trench crossing over from side to side of the road in order to

minimize the number of manholes required. In dealing with water mains, gas mains and other conduits made of iron pipes, it is generally possible to adjust the joints of the pipes so that the trench will follow the line of the road. For electric light cables laid in ordinary roads, especially in suburban districts, the conduits can be placed with advantage under the footways unless the latter are constructed with concrete or asphalt, surfaces which are hard to repair in the event of their being disturbed.

Hungary. JOSEPH MIHÁLYFI and DIDIER JÁSZ. In Budapest each of the footways is usually one-fifth of the total width of roadway and varies in other instances from about 5 feet to 25 feet in width. The sewer is generally placed in the middle of the street. On streets less than 49 feet in width the gas main is placed on one side of the street under the roadway, 3.3 feet away from the curb, and the water main occupies a similar position on the other side of the street. The electric light and telephone cables are laid under the sidewalks as near the houses as possible. The telephone cables are placed in concrete block conduits which contain in some cases as many as forty-eight cables and are placed sufficiently deep so that the other services to the houses can pass over them. On streets of a greater width than 49 feet there is placed both a water main and a gas main on either side of the road, 3.3 feet and 6.6 feet away from the curb respectively. On streets of a still greater width, 82.0 feet and more, on each side of the road the pipes are placed as follows: a water main at the curb, then the secondary street sewers, and, at a distance of about 10 feet from the curb, the gas main. Gas mains are placed under the road at a depth of from 3½ feet to 5 feet. Water pipes are generally laid from 4½ feet to 5 feet below the surface of the pavements.

CHAPTER XX

TRAMWAYS ON ROADS AND STREETS

BONNEVIE, AUGUSTE, *Chief Engineer of Railroads,* Brussels, Belgium.

GALLIOT, FRANÇOIS, *Chief Engineer of Bridges and Roads,* Dijon, France.

GELINCK, W. G. C., *Engineer of Waterways,* Assen, Netherlands.

GERLACH, FRIEDRICH, *Imperial and Municipal Commissioner of Public Works,* Berlin, Germany.

SPITERI, JOSÉ RODRIGUEZ, *Chief Engineer of Highways, Canals and Harbors,* Malaga, Spain.

TOLLER, GINO, *Engineer,* Milan, Italy.

ULLMAN, G., *Chief Engineer of Tramways,* Vienna, Austria.

VAN HEYST, D. A., *Engineer of Waterways,* Zütphen, Netherlands.

VON SZTRÓKAY, STÉFAN, *Chief Engineer,* Budapest, Hungary.

WALLAND, C. B. J., *Engineer of Public Works,* The Hague, Netherlands.

WYNNE-ROBERTS, R. O., M. Inst. C. E., F. R. San. Inst., Westminster, London, England, Great Britain.

Austria. G. Ullman. The only advantage of constructing a railway on the road is the saving to the railway company of the money that would otherwise have to be spent for a right of way and a probable increased cost of construction. The disadvantages both from the standpoint of the railroad company and of those who have charge of the upkeep of the adjoining road are many.

Government highways may be used for light lines without compensation having to be given, the railway company being liable for all expenses accruing from the reconstruction of the roadway necessitated by the installation of the track and for the maintenance and cleansing of that part of the road actually made use of by the line. The company is not liable for the costs of strengthening bridges or the maintenance and cleansing of banks and ditches along the lines. When the track is built along the side of the road it may be separated from the rest of the roadway by some kind of barrier but only when it is done in a manner which will permit the rapid removal of the barriers in case of need. The rail gauges used in Austria are 2.49 feet, 3.28 feet and 4.71 feet.

Belgium. Auguste Bonnevie. In Belgium, outside the built up districts, the track is usually laid on one side of the road or on an elevated bank inaccessible to ordinary traffic. A minimum width from track curb to the center of the road of about 20 feet on a rural road and of 23 feet on a main highway is required. When the track is constructed along the roadside the surface drainage is obtained by laying open stone drains underneath the track and leading to the ditch. The rails are of the Phœnix type with a groove about 1½ inches wide. In places where the rails cross a metalled road, the metalling is generally replaced

with stone block pavements over a suitable area. The rails both on the paved portions of the road and on the roadsides as well as on special tracks are fixed on creosoted oak sleepers.

The construction of railways on the road is always disadvantageous to the concession holder on account of the reduced speed at which the cars have to be operated and the increase in expense of track maintenance. On the other hand, it often happens that the interest of the people to be served is better accommodated by a line running in the roadway, since it affords easier access to their homes or places of business. The only advantage which the use of an existing road for a track may offer is the relief of maintenance of that part of the road used by the track. Where a track is constructed on a paved road, especially if it is a double track, this advantage may be of some importance.

When the track is built in a metalled road, the cost of maintaining the road is increased. The rails interfere with good construction.

Statistics show, that in Belgium at least, the number of accidents caused by railways being built on the roads are very few.

From the reports of 70 light railway companies which sent in replies to the list of questions regarding rail tracks to the Tramway and Light Railway Congress of Munich, it is found that there were very few which used longitudinal concrete supports under the rails.

France. François Galliot. A decree was issued in France in 1906 by the Ministry of Public Works prohibiting the construction of tramways on roads save in exceptional cases. The railway company is obliged to maintain the area between the rails and an area 1.61 feet outside each rail.

Economy in construction is evidently the only reason which can be offered in favor of building a tramway alongside the road. Taking everything into consideration one must come to the conclusion that in hilly countries the location of tramways alongside the public roads can be recommended only in extreme cases. One is, therefore, led to the conclusion, when considering nothing else but the railway, that laying it alongside the road may be compulsory in mountainous countries, but generally speaking it will be preferable to provide an independent right of way for the tramway in countries of average hilly character.

In cases where it is necessary to lay the tramway upon the road, if the track is so placed as to be inaccessible to the road vehicles, its deleterious effect upon the road is reduced to a minimum. Under these conditions all important kinds of road work, such as resurfacing and repairing, can be carried on in the usual manner with little inconvenience. In the case of tracks laid along the road that are accessible to the road vehicles the use of ordinary methods of maintenance is either very difficult or even ineffectual. Where grooved or twin rails are used, resurfacing can be carried out between the rails provided it is done very carefully, but where the other types of rails are used it becomes very difficult. The space between the rails in this case has to be maintained by special hand labor and is a source of continual trouble to the road builder.

Germany. Friedrich Gerlach. The maintenance of any surface adjacent to the tram-rails which are laid in the roadways gives more trouble and is more costly than the same road surface under the same traffic but without a track. The up and down movement of the rails under traffic is very injurious to the adjoining pavements, hence

the importance of a solid bed for the rails must not be overlooked. In the case of some pavements the rails may be laid on ties bedded in good gravel without any material damage resulting. Asphalt and wood block paving, however, are susceptible to a very small movement of the rail both laterally and vertically, and hence the most rigid bed is none too good. With the increase in the weight of the rolling stock and the introduction of electric traction, the rail sections and the track construction have had to be changed in order to stand up under the traffic. One of the principal objections to the usual method of concrete foundations for the rails is that the track cannot be used until the concrete sets up, thus sometimes causing expensive delays. To overcome this objection and to provide a foundation that can be rapidly constructed the Reinhardt method of construction was developed in Germany. A description of the latest improved form is here given. It consists essentially of rectangular shaped reinforced concrete blocks about 5 inches thick, 31 inches long and 20 inches broad. The block is so molded that in the top surface a trough is provided which is wide and deep enough so that when the rail is set in it the head of the rail will be flush with the surface of the block. Bolts are provided in each block so that rail fastenings may be put in and be attached to the rail base. The whole block is thoroughly reinforced and the reinforcing rods are allowed to project beyond the faces of the blocks which are parallel to the rail so as to bond with the concrete that is later put in between the rails. The blocks are placed in the bottom of the trench in which the rails are to rest and are first covered with a viscous asphalt. They are then pushed under the rails which have been jacked up to receive them and the rails are then screwed down to the

fastenings. The space between the bottom of the blocks and the earth roadbed is then carefully filled with a dry mixture of concrete which is carefully tamped. After a fairly long section is completed in this manner, the bolt holes are run in with liquid cement and the space left between the rails and the side walls of the reinforced concrete troughs is filled with asphalt. The space then left between the faces of the blocks between the rails is filled with well rammed concrete. These reinforced concrete blocks are laid close enough together so that the joints between their ends are practically closed up by pouring them with cement mortar. Cross ties are done away with. In this construction the rails do not come in contact with the concrete at all, but, on the contrary, are separated from it by the lateral projections of the reinforced concrete blocks and from these again by asphalt. In cases of renewal the asphalt can be readily removed by means of heat, and after the nuts are unscrewed from the fastenings, the rails can be easily lifted out.

Great Britain. R. O. Wynne-Roberts. Light railways on British roads must have one row of granite blocks or other suitable material having an average width of 6 inches on each side of the rails and, if laid on the waste land along a road, provision must be made for the drainage of the road.

In almost all of the populous centers in Great Britain tramways have been laid on public streets and roads. The foundations for these tramways are generally constructed of Portland cement concrete. Although in some cases a tramway has been laid on one side of the road, the general practice is to lay the rails in or near the center. Stone block and wood block pavements have been used for

construction between and outside of the rails. When the rails are laid in the center of the road the traffic is, in proportion to the frequency of the service, prevented from using the best portion, namely the crown of the road, and also from passing from one side to the other. On the other hand when the tramway cars pass at more or less prolonged intervals the vehicular traffic tends to follow the rails and causes tracking on the marginal pavements.

Hungary. Stéfan Von Sztrókay. Although no law exists, the light railways outside of the large towns are laid on permanent ways of their own outside of the road limits.

The tramways in Hungary generally use the grooved rail. The stepped rail so common in America is not used at all. There are some instances, however, on roads with a light traffic where the ordinary T rail section is used and the groove is nothing more than a furrow next to the railhead cut out of the adjoining pavement. In order to obtain this arrangement the macadam pavement is first completely finished without any regard being paid to the track and then the groove is cut out with a pickaxe. The ordinary grooved rail section which is rolled at the mills is not used very often in Hungary. The fixed groove can not be widened out where curves occur and hence the groove is generally wider on the straight stretches than is absolutely necessary, thus being unfavorable for the ordinary road vehicle traffic. The objections just cited may be done away with and a grooved rail may be obtained by the use of the Haarman twin rail which is used in Budapest. This system consists essentially of two bearing rails which are of equal height and width, both having a stepped head. Each rail of the track is made up of two of these rails laid so that the stepped heads form a groove. A special form of flange is used on

the wheel wherein the projection on the flange lies in the middle of the tread with the result that two treads bear on each rail. The joints are bolted together by means of a fishplate which lies between the two rails. By laying the rails so that the joint for one rail comes opposite the middle of a rail length of the other rail only one-half of the whole section is interrupted at each joint. The result is that the strength at the joint is 10 to 15 per cent greater than the section of the twin rail. This is the only system, so far as the writer is aware, where a double bearing surface is provided.

Italy. Gino Toller. Light railways may be constructed on the public highways provided a clear width of about 13 feet, measured from the outside of the cars, is left for the vehicle traffic. On bridges and for short lengths through built up districts and in the case of special obstacles, a smaller clear width is allowed.

In Italy there are 2,497 miles of tramways, 2,217 miles of which are built with Vignole rails and 280 miles with Phœnix and Hartwick rails. A majority of Italian tramways, 61 per cent, make use of the Provincial Roads, 25 per cent of them use the Communal Roads, and 9½ per cent have special ways of their own. As to the systems of traction, about 81 per cent are steam and 19 per cent are electric, but nearly all the recent lines are electric.

Where the Vignole rail is used it is impossible to use any form of metalling between the rails. The tramways are placed generally at one side of the road and the surface occupied is shut off from the ordinary carriageway.

The additional maintenance expenses on a road where a tramway exists are not easy to estimate. As a result of an inquiry made by the writer, in several provinces it was

found that the increase varied from 5 per cent to 20 per cent and even then the road surfaces were never in very good condition.

Netherlands. W. G. C. Gelinck and D. A. Van Heyst. Sanction is given to the construction of a tramway on a National Highway only under a series of conditions or regulations drawn up according to a standard form. Some of the more important stipulations are the following:

1. In designing the tramway the greatest possible width must be left for the ordinary road traffic. The track must be so laid that the road drainage is not interfered with.

2. Where the track is laid on a paved road, the cross sleepers must be so placed that their upper surfaces are at least 2 inches below the lower surface of the paving. Where the track passes over a masonry bridge, the thickness of the layer of ballast between the extrados of the arch and the under side of the sleepers must be at least 10 inches.

3. At crossings the railway company must lay down paving that will not interfere seriously with either the drainage or the ordinary traffic. The longitudinal slope of the road must not be steeper than 1 in 100.

4. Double lines are to keep to the same side of the road as the main line and shall be so constructed as not to encroach on the carriageway.

5. Where the rails are flush with the surface of the road they must be grooved or be provided with guard rails, say, of flat plates on tangents and of regular guard rails on curves.

The gauges of the tracks in the Netherlands are 2.46 feet, 3.28 feet, 3.5 feet and 4.71 feet. The rails are generally of the Vignole type fixed to cross ties. Where the rails are

laid flush or sunk in the road surface, supports are fastened between the foot of the rails and the sleepers. On most of the tramways where cross tie construction is preferred to the longitudinal supports, the ties are bedded in ballast almost always composed of sand which gives rise to much dust.

Netherlands. C. B. J. Walland. The subsoil of The Hague consists nearly everywhere of firm and sandy ground. In the older parts of the city this subsoil has acquired, in consequence of the traffic, a greater density than in the more recently developed quarters. On streets paved with stone block or brick, the subsoil was deemed to be sufficiently compact to allow the rails to be laid on the sandy substratum without taking special precautions, since it was thought that during the first few years the work of constantly raising the rails to the desired level would be cheaper than the extra cost of building a solid foundation, and experience has substantiated this opinion. The Phœnix grooved rail was chosen as the appropriate rail section. Although this method of construction was satisfactory where stone block or brick pavements were used in the adjoining road surface, it was not successful for the track construction where the rails had to be laid in an asphalt pavement.

In this latter case a solid bed of concrete was placed in the track trench. After this bed had sufficiently set up, the rails were laid on it and brought to the correct level by means of wooden wedges placed at intervals of about 6 feet in such a manner that the distance between the surface of the concrete bed and the rail base was about 1¼ inches. Then the footing of the rail was surrounded with a bed of poured asphalt. Along the rails on either side hard Australian wood blocks were laid. This form of con-

struction did not work out particularly well because it allowed a vertical movement of the rail, which disturbed the wood blocks, permitting water to trickle in. It was found on making an examination that the asphalt no longer completely adhered around the rail, although the wooden wedges on which the track had been laid were in good condition. It was also observed that the movements of the rail first commenced at the rail joints.

To remedy these objections the method of construction has been modified. Asphalt is no longer poured under the rails and the latter are placed on oak sleepers having a width equal to the base of the rail and a thickness of about 1½ inches. The sleepers are firmly fixed to the rails after the rails have been brought to the desired level. The bed of concrete is then finished and is so applied as to adhere perfectly to the sleeper. At the joints both the sleepers and the rail base are anchored to the concrete. In roads where it is necessary to fix the rails which become loose, and when the method just described can not be adopted, a poured bed of asphalt is provided under the rails and the wedges on which the track rests are placed at intervals of 20 inches instead of about 6 feet.

Spain. JOSÉ RODRIGUEZ SPITERI. The construction of the tramway along the road or public highway brings with it difficulties, nuisances and even danger to pedestrians and vehicles. If the tramway must be placed on the public highway, it should be placed on that side which causes the least possible interference to the road in the case of a single track line. If it is a double track, as there is usually not sufficient width to allow a double track to be constructed in the center of the roadway, the tracks should be placed one on either side, care being taken to leave in the center

a width of about 15 feet for the ordinary traffic and two side clearways to the outside of the rails which should have at least a width of about 20 inches beyond the profile of the rolling stock. If the tracks are accessible to the horse drawn traffic, they should be built flush with the road surface. In order to fulfill this condition grooved rails must be used, such as the Phœnix type, or they may be also of the twin or double type. They should be laid in concrete beddings or on longitudinal sleepers. Wooden sleepers should be given up because they allow too great a flexibility in the track. Metal sleepers considerably increase the cost of construction since they have a short life.

The tramways of Spain are for the most part constructed on longitudinal concrete sleepers, and up to the present nothing has occurred to convince us that this is not good construction. Some people say that the undulatory wear of the rails is liable to occur or is brought about by a too rigid foundation. We have, however, not been able to confirm such an opinion on the various lines in Spain.

Thus it appears to us that the best system of laying a tramway track is to place the rails on a system of continuous concrete blocks, the cross-section of which is proportionate to the resistance and the ground conditions, a section measuring never less than 6 inches in height, and always extending more than 2 inches beyond each side of the rail base.

Due to the fact that the rail joint is the weak spot in a flush track, recourse should be made to the continuous track or to some method of directly welding the rail.

The ordinary regulation, which allows railway companies to construct the area between the rails and the areas in direct contact with the adjoining roadway with the

same material as is used in the roadway, does not always produce good results even if one row of stone blocks is laid next to the rail with their greatest dimension parallel to the track. The space between the rails and the areas outside of each rail of about 19½ inches in width should be paved with a well selected material, very hard and resistant, bedded on a solid foundation. Where reasons of an economic character would not permit of this construction, the breadth of the surface paved between the track may be reduced to a single course of paving each side of the rail, the remainder of the area to be made up of the same material with which the roadway is constructed. The rail track of the tramway should conform as much as possible to the cross-section of the road and particular care should be taken that the joints of the surfaces should be made in such a manner as to prevent the accumulation of water.

CHAPTER XXI

PUBLIC SERVICE CONVEYANCES

ALBERTINI, ANTOINE, *Director of Engineering Department, Province of Modena*, Italy.

DE HEVESY, GUILLAUME, *Civil Engineer*, Budapest, Hungary.

DE FUISSEAUX, H. L., *Chief Engineer, Director of the Autobus Company*, Brussels, Belgium.

HANSEZ, JULES, *President, Touring Committee, Royal Automobile Club*, Brussels, Belgium.

MARIAGE, A., *Chief Engineer, Omnibus Company*, Paris, France.

PÉRISSÉ, LUCIEN, *Engineer of Arts and Manufactures*, Paris, France.

SMITH, EDWARD SHRAPNELL, *Member of Committee, Royal Automobile Club*, London, England, Great Britain.

WILLIAMS, BENJAMIN W., *Councilor of the Borough of Southwark*, Walworth, London, England, Great Britain.

Belgium. H. L. DE FUISSEAUX. Among the advantages of the modern motorbus the following may be cited:

1. No disturbance to the ordinary traffic.

2. The first cost of establishment neither causes deterioration of the road surface nor does it require the deviation of public services such as water, gas and electricity.

3. The maintenance and cleansing of the public high-

way is easier than is the case where the rails of a tramway occupy a portion of the road.

4. The possibility of diverting a service readily at short notice as in the case of processions or public festivals on one of the streets travelled over in the regular route, the bus passing through neighboring side streets, thereby permitting the maintenance of traffic and the rapid handling of the same.

5. No hindrance to the drawing up of ordinary vehicles at the sides of the highways.

6. No danger from the electrolysis of gas and water mains.

7. No danger of electrocution.

8. Less danger of accidents by running over people.

9. Smaller cost of transportation.

10. The greater safety for people in getting on and off, as the motorbus can approach the sidewalk to take on and let off passengers.

11. Fewer disagreeable shocks at the curves or on braking.

12. The greater regularity of running and the assured running while snow or ice covers the streets.

13. Less capital required for the establishment of the service.

14. Better revenue for the capital invested.

15. The possibility of creating provisional services.

16. The great facility in exploitation.

The disadvantages arising from the use of motorbuses are noise, splashing of mud, dust, odor and vibration. Such objections as noise and odor can be eliminated provided the car is in a proper state of repair and the operator is familiar with his work. The vibration caused by the car

is largely due to the condition of the road surface over which it passes and also depends upon the type of tire used on the wheels and the kind of springs with which the car is equipped. The dust nuisance can be avoided by properly cleaning the roads or by treating them with some suitable palliative. Mud splashing will not be a serious objection if the road surfaces are in good shape.

The following cost table is based on the assumption that a vehicle works eighteen hours every day and runs 74.5 miles:

	Cost per car mile
Petrol, oil, maintenance	$ .0414
Maintenance on 5 year guarantee	.0186
Chauffeur	.0311
Garage and insurance	.0186
Tires	.0342
Total	$ .1439

Belgium. JULES HANSEZ. Wherever the roadway has a perfect surface, motorbuses may render very considerable service. Where no tramways exist and where traffic is light the advantages of motorbuses should be seriously considered.

France. A. MARIAGE. In France and her possessions there are fifty lines on which are operated some form of motor power bus, the lines varying from about 3 miles to 317 miles in length. A majority of the lines pass over roads having maximum grades of 6 per cent to 9 per cent and in one case the maximum grade is 12 per cent.

With few exceptions the capacity of the body of the car is between ten and twenty seats. The total weight of the loaded car is usually between 6,614 and 13,228 pounds, with an almost constant axle load distribution of one-third on the front axle and two-thirds on the back axle. The

power for these vehicles is supplied in the large majority of cases by gas engines but there are a few instances where steam is used, generated either by a liquid or a solid fuel. The power of the motors varies from 12 to 40 horse-power, capable of attaining speeds from 8 to 25 miles an hour. The cars never have more than two axles except in the case of the Renard system, where three axles are used on the trailers. The steering wheels are the two front wheels, the two back wheels being the driving wheels. The tires used may be either pneumatic, solid rubber, rubber blocks inserted in the rim, iron or steel. Although the pneumatic tire affords the easier riding, it cannot be used with economy except on light cars and the solid rubber tire is therefore the most common form of elastic tire. In order to prevent skidding the rims of the back wheels are divided into two parts. The Renard system, which is mentioned above, is used on two lines and is practically the only system employing trailers. The principle of the Renard system is to have one motor car capable of developing and transmitting power to each trailer forming the train so that each trailer is operated independently.

At the 15th International Tramway and Light Railway Congress held at Munich in September, 1908, the general reply to a question concerning the additional expenses for maintaining a road under a motorbus service was that an increase of expenses was necessary. In Corsica, the supplementary expenditure is estimated at $15.50 per mile per annum and in Côtes-du-Nord at 3.1 cents per mile run. In the Vendée the rural roads have been completely cut up and the administrative bodies estimate about $1,930 for each 20 miles as the supplementary expense of maintenance. In this last case, however, the vehicles were fitted with iron tires.

The writer collected information relative to public motor conveyances in several districts in France where such vehicles were used. As a result it was found that they had only recently attained a certain success. In general the results of exploitation were not very encouraging, due to the very high costs of operation. Since the costs are high, the traffic is restricted and the returns small, resulting sometimes in a loss.

The writer does not think that motorbuses and railways can be compared as neither one can be substituted for the other. The motorbus is desirable when the running expenses are immaterial such as for pleasure trips and when creating a traffic prior to building a railway. The only advantage the motorbus has over tramways at present is the lower initial cost.

France. LUCIEN PÉRISSÉ. The writer believes that two distinct classes of public motor conveyances should be recognized, the first class to include those used in large cities or towns and the second class those applicable to interurban use. The second class may be considered to include the motor omnibus which can render great service outside of towns, principally in making connections or acting as feeders between the stations of the main lines of the great railway companies for the transport of passengers and light weight goods. Further, in certain cases and at favorable seasons, such means of conveyance should serve to bring a stream of tourists to new centers and to the picturesque watering places. Lines of omnibuses can also serve as direct connecting links between two important centers which have only an indirect intercommunication by rail.

In the country where it is not possible to think of paving

many miles of roads, it is necessary to increase the resistance of the roadway used by motor conveyances by judicious choice of materials in its construction.

Great Britain. EDWARD SHRAPNELL SMITH. The outstanding advantages of the motorbus, which are peculiar to it in comparison with the electric tramcar, include:

1. Low capital outlay involved.
2. Absence of the necessity of obtaining special powers from the legislature.
3. Mobility of rolling stock.
4. Independence of a central power plant.
5. Non-interference with other traffic.
6. No rails and no overhead equipment.
7. Low working costs now achieved.

Advocates of electric traction four and more years ago, at the time when motorbus operation was still in its infancy, had seven chief points of attack, as follows:

1. Great noise and consequent inconvenience to other users of the road and to those residing along the streets where they are operated.
2. Odor.
3. The ever present danger of side-slip.
4. The danger of fire.
5. Vibration.
6. Danger to other vehicles on the highway.
7. Unreliability.

To-day there is no justification for these objections.

Sir Herbert Jekyll, K. C. M. G., the Head of the London Traffic Branch of the Board of Trade, in a report issued in January, 1910, said: "As rivals to tramways, motor omnibuses are likely to become more formidable than they have been hitherto, since they will be cheaper to work, and

will travel longer distances than heretofore. Tramways have long since reached a stage at which there would appear to be little room for further improvement either in efficiency or cheapness. Motor omnibuses, on the other hand, are only beginning to show their capacity for dealing with traffic in large volume, and there is still an ample margin for improvement. As a means of transportation, the omnibus is in its infancy, whereas the tramway has come to maturity."

The London General Omnibus Co., Ltd., has not failed to pay dividends in the past three years. This company owns fully 1,000 motorbuses which will all be put into service during the summer of 1910.

In London not infrequently at the busiest hour of the day as many as 9,000 passengers per hour are conveyed along certain thoroughfares by motorbuses, having thirty-four seats. A bus can not carry standing passengers either inside or elsewhere. With larger bodies the writer sees no reason why the capacity for passenger traffic by means of motorbus cannot be safely put as high as 20,000 passengers per hour in each direction where there is a call for such concentration.

Great Britain. Benjamin W. Williams. The number of passengers carried in London last year varied from 700 to 800 millions of which 300 millions were carried by motorbuses. Tramways and motorbuses must be considered as modes of transport which have advantages over one another according to the districts which they serve. The traffic of these motorbuses has no special effect upon the road owing to the existence of ordinary automobile traffic. The roads must be constructed in accordance with the requirements of this class of traffic.

Hungary. Guillaume De Hevesy. The Hungarian government is experimenting with a motorbus train after the Renard type, consisting of two driving cars of 70 horsepower each, four trailers each carrying a load of 3.5 tons and a residence car. It is intended to use this train in maintaining a stretch of government road about 155 miles in length in the County of Pest and this system is expected to show a large saving in the cost of transportation of road material.

The writer thinks that the special field for the utilization of the motorbus is in those branches of activity where the introduction of cheap transport by road would be of great advantage, as for example in:

1. The building industry including brick factories, motor and cement works, stone and asphalt industries, etc.
2. The exploitation of mines, including quarries.
3. The transportation of raw materials for factories.
4. The delivery of wood, coal, etc.
5. The transportation of food stuffs for the towns.
6. The transportation of agricultural raw materials.
7. The lumber industries.

Italy. Antoine Albertini. The Maranello-Pavullo line has been successfully operated in the Province of Modena, Italy, since 1906, and furnishes a motorbus service using cars with a capacity of twelve to twenty-four passengers.

If by means of a motor service for passengers only, like those in Italy, a sensible increase, constant and regular, occurs in the ordinary number of travellers over a certain route, the laying down of a tramway or railway might be justified. For the success of such a service gives proof of the existence of a latent, economic potentiality, which only

awaits the means to enable it to be revealed for the good of the inhabitants. This is the principal advantage that will be derived from a motorbus service. A public automobile service cannot therefore be considered a permanent one either in populous districts or in those mainly devoted to agriculture; it is only a temporary arrangement.

Before the installation of public motorbus services, the road to be used should be prepared and adapted to such service. Provisions should be made for the maintenance of the road by spreading fresh layers of stone over the whole surface and rolling it.

CHAPTER XXII

HIGHWAY BRIDGES

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CHRISTOPHE, PAUL, *Principal Engineer of Bridges and Roads,* Brussels, Belgium.

DE NOVÁK, FRANÇOIS, *Technical Councilor to the Royal Ministry,* Budapest, Hungary.

DESCANS, LÉON, *Engineer of Bridges and Roads,* Ghent, Belgium.

RÉSAL, JEAN, *Inspector-General of Bridges and Roads,* Paris, France.

Belgium. PAUL CHRISTOPHE. On the Government roads in Belgium, bridges must be calculated first for a uniformly distributed load of 82 pounds per square foot and, next, for a load of 18 tons on two axles. If the travelled way is wide enough to accommodate them, the bridge shall be calculated for two such axle loadings side by side. The axles are about 10 feet center to center and the rear axle is assumed to carry 10 tons. The gauge of the wheels of both axles is to be taken as 5.6 feet and the distance between two trucks side by side 5.2 feet. Each truck is supposed to be drawn by ten horses, each animal weighing 1,543 pounds. The total weight of the truck and team is, therefore, 25 tons. This load is distributed over an area of 60.7 feet by 10.8 feet. If trucks with their teams are replaced

by auto trucks of the same weight and the same conditions of crowding are allowed on the bridge as under the present regulations, the auto trucks will strain the bridge more due to the closer spacing of the loads.

Motor cars of the lighter type have no influence on the elasticity of bridges since the vibrations they produce are absolutely imperceptible. With regard to heavy motor vehicles no conclusions can be drawn because the experiments carried out with them are not very numerous. Although speed is able to accentuate to a sufficiently noticeable extent the effect of rolling loads on bridges, there is nothing that would lead the writer to suppose that the progress of automobilism would aggravate the situation, unless very heavy engines come into a more general use as a means of conveyance.

The writer has concluded from tests made under his direction that if the various members of a metallic bridge are firmly held together to form a perfectly united whole, they can be made just as rigid, and are consequently able to resist the dynamic effects of rolling loads just as effectually as bridges of reinforced concrete, for which a superiority in this respect is sometimes claimed.

Belgium. Léon Descans. The stringers of bridges will act in one of the three following ways dependent upon the end connections:

1. As a beam simply supported at the ends.
2. As a continuous beam with the ends free to rotate.
3. As a continuous beam with the ends fixed.

From calculations it may be proved that under certain assumptions the continuity of the stringers will reduce the deflections of the floor by about one-half under the passage of rolling loads. The continuity of the stringers combined

with a system of connections with the cross girders, which will prevent the rotation of the stringers over the points of support, will reduce the deflections to about one-quarter of their original values. It is, therefore, desirable that the connections between stringers and cross girders should be as rigid as possible. The connections between the stringers and cross girders must be calculated with a view to make them strong enough to resist the bending moments in the stringers as continuous girders. Although the continuity of the stringers necessitates the strengthening of the connections, it reduces, on the other hand, the maximum bending moments in these members. Nevertheless, it will be advisable to design the stringers on the assumption that each span is an independent beam, merely supported at the ends, due to the fact that the stiffness really due to the supports and the strains produced thereby are only imperfectly known.

France. JEAN RÉSAL. On special structures of masonry, where the dead load is very considerable in comparison with the weight of the heaviest vehicles which may circulate on the roads, the influence of weight should be considered as negligible.

On special structures of reinforced concrete it does not seem that an opinion deserving full confidence can be expressed at the present moment, since this method of construction has been practiced for too short a period to allow a formal conclusion to be deduced.

There remain bridges constructed of metal or wood, on which subject theory and practice furnish data sufficiently complete and precise to permit an answer to be given to the question raised. The conclusions, which we shall be led to draw from a study of this subject, can be extended, at

least provisionally, to reinforced concrete structures, under reservation of new facts, which in the future will either complete or modify the still very imperfect knowledge which we have of the elastic properties of the hybrid material.

In the case of steel bridges the theory of the effect of a moving load on the bridge is that the vibrations caused by such a load in the course of time weaken the metal by a molecular transformation which makes the metal brittle. The writer believes that this would only occur if the vibrations have the effect of increasing the elastic work up to the elastic limit, or in the case of metal that is not properly manufactured.

There are in existence many large steel bridges which apparently show no signs of crystallization of the metal even though they have been subjected to moving loads whose weights and velocities have been increased in a marked degree since the construction of the bridges. This fact may be due to the margin of safety, or factor of safety, as it is commonly called. Provided that the metal in the bridge is of the proper kind and the workmanship, particularly the riveting, is properly done, the writer believes that experience shows the practice followed by designers insures proper stability. Since high speeds will only be attainable by automobiles equipped with elastic tires, it seems inadmissible that the fastest cars, whatever their weight, limited moreover by the necessity of having an expensive tire, should be capable of subjecting a bridge to shocks comparable with those which it actually sustains from the passage of ordinary wheel traffic.

Great Britain. W. Worby Beaumont. Upon a perfectly smooth road surface vehicles with smooth metal tires or rubber tires would not give rise to impact forces. Im-

perfection of balance of the motor machinery may be omitted from consideration in this question with regard to a perfect road surface or an ordinary road surface. Imperfections of road surface must, therefore, be looked upon as the primary cause of the interacting disturbances set up by the passage of motor vehicles. These disturbances increase as the weight of the vehicle, as the square of its velocity, and in various ratios greater than arithmetical proportion with the increase in roughness and irregularity of the road surface.

In general it may be said that in questions involving consideration of harmful vibrations created by the passage of heavy vehicles over common roads, greater attention should be directed to the limitation of speed than to the limitation of weight, provided that the latter is within the limits now laid down by the authorities in the United Kingdom. That attention has been properly directed to these limits is sufficiently shown by the following figures of maximum speed and weight as now authorized:

Nos.	Total Weight of Vehicle and Loads in Tons (W)	Maximum Speed Permitted. Miles per Hour (V)	Material of Tires	WV^2	Momentum	Comparison of Weight
1	12	5	Iron	300	1.00	3.43
2	9	8	"	576	1.92	2.57
3	12	8	Rubber	768	2.56	3.43
4	9	12	"	1296	4.33	2.57
5	3.5	20	"	1400	4.67	1.00

These figures suffice to show that the product of W and V^2, which is an index of the violence of impact, is greater with the lighter vehicles at their higher permitted speeds than with the heavier at their lower allowed speeds, and that as the load becomes greater and therefore approaches more closely the limit of load which the road will carry without

injury to foundation or displacement of subsoil, so the disturbance due to impact is lessened by reduction of speed in a greater inverse ratio than that due to the ratio of increase of weight.

Hungary. François De Novák. Regulations are in force in Hungary which govern the design and the use of the highway bridges. Bridges of the lowest class are designed for vehicles weighing from 3 to 6 tons, while bridges of the first class are designed for loads of 12 to 24 tons. It has been observed on one bridge that a steam-roller weighing 13.5 tons did not produce as much oscillation as a horse drawn vehicle weighing 1.5 tons, due to the rhythmic motion of the animals. The dynamic effect of an automobile differs from that of a horse drawn vehicle and although the motor cars travel at greater speeds, the fact that they are provided with pneumatic tires prevents as great a dynamic effect being produced. A sudden application of the brakes of a motor car while on the bridge may cause a considerable shock to a small structure, but the road bridge covering can generally resist these forces.

CHAPTER XXIII

TIRES

ARISI, T., *Engineer; Member, Automobile Club of Italy*, Italy.

BAUDRY DE SAUNIER, L., *Member, Automobile Club of France*, France.

FERRUS, COMMANDANT L., *Member, Automobile Club of France*, France.

HANSEZ, JULES, *President, Touring Committee, Royal Automobile Club*, Brussels, Belgium.

JANSON, J. H., *Secretary of the Touring Club of Netherlands*, Netherlands.

LUMET, GEORGES, *Engineer of Arts and Manufactures*, Paris, France.

MALLOCK, A., E. R. S., *Royal Automobile Club*, London, England, Great Britain.

STEFFELAAR, L. C., *President of the Touring Club of Netherlands*, Netherlands.

Belgium. JULES HANSEZ. The action of a pneumatic tire on the road surface is mainly frictional, due to the fact that at certain speeds the wheels jump, owing to the inequality of the road surface and the elastic deformation of the tire. Trials have been made with distance recorders and it was found that the distance indicated between two towns was greater with the smooth than with the non-skidding tires. In skidding the wheels do much more dam-

age to the road surface than in rolling. In wet weather a non-skidding tread is indispensable to the safety of the passengers. Chains, steel rivets and rubber studs are some of the devices used to prevent skidding. The leather cover studded with steel rivets is the most popular form for use on the pneumatic tire. For large and powerful vehicles the writer recommends twin pneumatic tires on each rear wheel. The advantages in favor of twin tires are many, both from the standpoint of the automobile and the road.

France. Commandant L. Ferrus. Pneumatic tires furnish comfortable riding, preserve the machinery, permit the use of much higher speeds, and produce a saving in tractive force. As a result of experiments made with different makes of tires for different speeds and for air pressures in the tubes of about 13 pounds and 5 pounds, it has been found that the best solid tire required practically the same tractive force as the best pneumatic tire and that the tractive force increases when the air pressure in the tube drops from 13 to 5 pounds.

Since pneumatic tires cannot, as a rule, be subjected to pressures of more than 1,300 pounds, their use will be limited to light vehicles. Experiments have been made in France by the Compagnie Générale des Omnibus in fitting their 5 ton omnibuses with twin pneumatic tires. Excellent results have been obtained with respect to comfortable riding, but the cost of the tires in this particular experiment has proved to be absolutely prohibitive.

Solid tires in actual use may be divided into three main classes:

1. Continuous hoops of a half round or nearly half round section vulcanized on the rim. These may be used either as single or twin tires.

2. Continuous hoops, generally of trapezoidal section and fixed to the rim by steel rods. These tires may also be of the single or twin type.

3. Sectional tires or blocks.

Continuous tires have a very serious fault when used on heavy motor omnibuses, such as those commonly running in cities like Paris, as they are too liable to skid when the pavement is at all greasy. Skidding is very much less pronounced when the wheels are fitted with twin tires. On the other hand blocks have given every satisfaction with respect to non-skidding, but they are not as satisfactory as continuous hoops with respect to the absence of vibration. The tires with rod fastenings have the same advantages and disadvantages as the hoops vulcanized on the rim.

A spring wheel is a wheel that is deformed elastically in such a manner as to take up all the jolts of the road without ceasing to fulfil its ordinary duty. There are many different types of these wheels, some have rigid outer rims and develop the elastic feature from the center of the wheel by means of air, others use an elastic material on the rim, which would include wheels equipped with any form of rubber tire. Still another type is the elastic wheel with the non-continuous flexible outer rim such as the Brillie wheel with radial pistons supported on round india rubber pads. There are only two types of these wheels that show signs of satisfying the requirements for motor cars. They are the Lipkouske and the Partington wheel.

France. Georges Lumet. The weight, width of tires, diameter of wheels and the speed of a vehicle are all factors which affect the life of a road. The consideration of speed is not of as much importance in the case of horse drawn vehicles as it is in the case of those mechanically

driven. If the relation between the load carried, the width of tires and the diameters of the wheels is properly fixed for horse drawn vehicles, they should not cause extraordinary damage to the roads. The high speeds at which motor vehicles travel, however, accentuate the effect of the vibrations of the car which otherwise would not be at all deleterious.

It is the writer's opinion that industrial transport by means of motor vehicles, with engines working with explosive mixtures, cannot cause any damage to the road surface provided they are kept within the following limits as regards speed and weight:

Class 1. Average speed 10 miles an hour; maximum speed 15.5 miles an hour.

Greatest pressure on the tires per inch of length of the circumference in contact with the ground, to be equal to 840 pounds, with wheels not exceeding 3.28 feet in diameter. Greatest width of tire, 6 inches.

Class 2. Average speed 6 miles an hour; maximum speed 9 miles an hour.

Greatest pressure on the tires per inch of length of the circumference in contact with the ground, to be equal to 840 pounds, with wheels not exceeding 3.25 feet in diameter. Greatest width of tires specified is applicable to those rubber tires in which the rubber is in contact with the ground. For other tires it will be necessary to ascertain by experiment the greatest width to be prescribed so that the distribution of the load on the ground may be effected under normal conditions.

The writer believes that some form of armored tire may prove to be less destructive to a road surface than the smooth tire, since it prevents slipping of the wheel. It

is known that where a wheel revolves on the same spot, through want of adhesion or by reason of its leaving the ground, it may be made to slip sideways by a slight lateral push and may give rise, in this way, to very destructive transverse forces.

The sudden starting or braking of a car causes serious wear to the road. The application of the brake should produce a retarding force on the drum in order that work may be produced, the result of the friction between the strap of the brake and the drum. It is this work which counterbalances the kinetic energy of the vehicle, and it is easily understood that it is more advantageous to collect this in a part of the machine specially provided for this purpose, than to let it expend itself as friction between the wheel and the road, to the great detriment of both.

France. L. Baudry De Saunier. The principal duty of the soft tire is to absorb the lateral reactions to which a vehicle is exposed, and which greatly hinder its progress. Consequently the soft tire, although it does increase the coefficient of rolling friction eliminates the numerous small retarding lateral forces to which the vehicle is subjected.

Great Britain. A. Mallock. When there is loose material on a road surface, any traffic will cause deterioration, but if the surface is free from loose pieces and is held together by some elastic or viscous binding material, wear does not take place unless the intensity of the pressure is sufficient:

1. To disintegrate by crushing the stones of which the road is formed;

2. Or to cause some permanent displacement of the binding material.

When iron tires are used the intensity of the pressure

at more than very low speeds is always greater than that required to satisfy the first condition. With soft tires the case is very different. The intensity of the pressure is then so light, not exceeding 100 or 200 pounds per square inch as against the 2,000 or 3,000 pounds per square inch exerted even at low speed by iron tires, that there is no difficulty in getting a surface which is not affected, and for a road intended for soft tires only there would be no occasion for using hard stone. For some time to come, however, hard tires and horse traction will, in the country at any rate, form a considerable part of the traffic, and the roads must be adapted to both classes.

Italy. T. Arisi. The supremacy of the pneumatic tire must be considered not only with regard to the better working of the machinery, but also with regard to the smaller fuel consumption and the road maintenance. Several trials have clearly shown a saving in petrol of at least 20 per cent in a vehicle fitted with pneumatic tires, probably due to these tires admitting the use of lighter wheels and transmission gear.

Many attempts have been made to provide a substitute for the pneumatic tire by means of spring wheels and suspensions but unfortunately all such devices have serious defects. Satisfactory trials allow us to hope that the pneumatic tire will come into general use for heavy loads. With the use of twin tires and by reducing the weight of the chassis to perhaps 2,500 pounds, a load of 4,500 pounds, body included, could be supported.

Netherlands. L. C. Steffelaar and J. H. Janson. The Netherlands is an agricultural country devoted extensively to the cultivation of beet root. Due to the fact that the crops of this product are all handled during a very

limited period, the roads suffer excessive damage and oftentimes become impassable for every other kind of traffic.

To remedy conditions the Touring Club of Netherlands suggested for adoption a set of laws regulating the width of tire, diameter of wheels, and weight of load. The laws, however, were only adopted in one province. With regard to the diameter of wheels and the widths of tires the following regulations were proposed: the maximum load including the weight of the vehicle which may travel on a road, is to be 565 pounds per inch width of tire for two wheeled vehicles, the wheels of which have a diameter of not less than 4 feet, 3 inches. The maximum load which may travel on a road in the case of vehicles with four or more wheels having a diameter of not less than 2 feet 8 inches, shall be 425 pounds per inch width of tire, provided that the load is divided among the axles proportionally to their wheel diameters. In times of thaw these loads are to be reduced one-half.

CHAPTER XXIV

CONCLUSIONS ADOPTED AT THE SECOND CONGRESS

First Question

METALLED AND PAVED ROADS. USE OF BINDING MATERIALS IN THE CONSTRUCTION OF METALLED ROADS. USE OF TRACKWAYS IN THE PAVED ROADS. PROGRESS MADE IN COMBATING WEAR AND TEAR AND DUST.

1. Use of binding materials in the construction of metalled roads. The Congress believes that it is desirable to pursue and develop the applications of the use of binding materials in the construction of metalled roadways, special attention being given:

a. To determine the character of the binder best suited to local conditions in each case;

b. To determine as far as possible the proper physical and chemical characteristics to be specified for bituminous binders;

c. To compare the different results obtained by various methods of construction;

d. To investigate the influence that the storing of tarred metal for a more or less extended period before being used may have upon the finished work;

e. To make a study of the deterioration which the materials are subjected to during use;

f. To specify the system to be recommended where ordinary metalling has proved deficient and stone paving can not for some reason be adopted;

g. To determine for each section of highway in a given district the relation between cost and the results obtained under known local conditions.

2. Use of trackways in paved roads. Except in exceptional cases the construction of trackways in paved roadways can only be considered an expedient.

3. Progress made in combating wear and dust. Confirming the resolutions passed at the Paris Congress in 1908, and in further reference to the first resolution just adopted which is of interest not only from the point of view of combating wear and dust but from that of binding the materials in metalled roads, the Congress believes:

a. That superficial tarring may be considered as definitely accepted in practice and that the advantage to be derived from spreading fine sand or suitable stony material after tarring and rolling the same is not at present proved and should be the subject of comparative tests;

b. That in the future applications of these methods the attention of road builders should be drawn to the comparison of results obtained by the laying of bituminous substances, hot or cold, by machine or by hand, both from the point of view of cost and from the point of view of the efficiency of the operation;

c. That it is desirable, in comparing results, to take into account the quality of the materials composing the metalling, the intensity of traffic and tonnage as well as the climate;

d. That, with due regard to the resources of each region in bituminous substances, it is important to specify in contracts, the conditions that are to

be fulfilled, especially as regards the preservation of "life," that is to say, the property of preserving the binding power;

e. That it would be desirable to establish a comparison between the advantages of tarring, this word being taken in its broadest sense, under different conditions, that is, whether the operations are to be frequently repeated, small amounts being applied each time, or whether large quantities are to be applied at longer intervals, and furthermore whether, or not, a bituminous substance has been incorporated in the metalling;

f. That the conclusion adopted by the first Congress is to be maintained "in toto" as follows: emulsions of tar and of oil, hydroscopic salts, etc., . . . have a real but not a lasting efficiency. Therefore, their use should be limited to special cases, such as race courses, festivals, processions, etc.

Second Question

Foundation and Drainage of Roads. Methods of Carrying Out the Work.

Foundation

1. The strength of road foundations should be increased in proportion as the supporting power of the ground decreases. The foundation should have more body and resistance, the more it is exposed to internal deterioration and external wear.

2. In the choice of the system of foundation for both stone block pavements and metalled roads, due considera-

tion should be given to the condition of the subsoils, with regard to the possibility of their drainage, to their geological nature and to the nature of the materials of the locality. In order to determine the thickness and the extent of the foundations, the pressure per unit area should be made compatible with the carrying resistance of the soils, observed under the most unfavorable conditions.

Drainage

3. In soils where preliminary drainage is required before the construction, the general methods of drainage should be applied to the whole or to a part of the road-bed and to the bed of the metal, if necessary.

4. The cross and longitudinal sections of roads and those of side-gutters should be so established as to facilitate the flow of water, and to prevent infiltration of water into road surfaces, which should be made as impermeable as possible. The evaporation of superficial dampness should be encouraged by every means.

5. The works for the foundation and for drainage should be carried out simply and economically and by using the materials of the locality as far as possible.

Third Question

Laying Light Railways and Tramways on Roads. Advantages and Disadvantages. Effect of the Various Methods and the Cost of Maintenance.

1. In the study of the new roads to be constructed both in the neighborhood of large towns as well as in the open country, it may be useful to try, if it does not interfere with the public interest, to provide a sufficient road width

for the construction of a light railway outside of the roadway. The alignment, gradients and the cross-sections should be so designed as to provide an economical and efficient railway and also provide for the safety of every kind of traffic. It is desirable that the cost of the right of way of that part of the road reserved for the rail track should be defrayed by the concession holder or the constructor of the light railway.

2. The construction of sunken rails in the metalled roadways is always detrimental to the life of the roads, and there also results a marked increase in cost of the maintenance of the roads. It is desirable that this method should be avoided as much as possible. The establishment of rails for tramways in paved roads makes the repair of the paving abutting against the rails very difficult. It is necessary to diminish that nuisance, as far as possible, by appropriate methods.

3. Where the railway is placed by the side of the road it is preferable, where the width of the road permits, to construct it on a special track, inaccessible for traffic, and superelevated in order to allow greater safety. In all cases it is necessary to provide proper drainage. In the case of metalled roadways, the concessionary or constructor of the railway should be obliged to construct on the outside border of the free roadside, sufficient depots for materials for the repair of the road. The same obligation should be, in some cases, applied to railways on paved roads.

4. The removal of trees along roadsides should not be tolerated, except in extraordinary cases. If the width between the tree rows is insufficient for the rail track to allow the recognized necessary width for ordinary wheel traffic, the track should be laid on the outside of the trees.

5. It is desirable that the concessionary of light railways should undertake the duty of maintaining the area of the road or roadway occupied by the rails or contiguous to same, and pay the costs of this maintenance.

Fourth Question

Cleansing and Watering. Necessity or Utility. Methods in Use. Their Cost. Comparison of Various Methods.

1. Throwing refuse upon the public roads should be carefully avoided. Such refuse should be swept up and removed by the municipality and not by the owners of adjoining property, provided the cost of this work is recovered from the latter by taxation.

2. In large towns it is necessary to give special care to cleansing and watering. Cleansing should be done as rapidly as possible. Watering must be frequent, and limited in amount depending on local conditions. Washing and sweeping are to be done as early as possible. Mechanical processes are particularly recommended.

3. Improvement in the machines are to be sought for with a view of insuring the most complete cleansing with the least inconvenience to the public. Motor machines can be advantageously used for cleaning and road watering in large towns.

Fifth Question

Choice of Surfacing Materials.

1. Macadam, constructed according to the methods of Tresaguet and McAdam, causes dust and mud, is expensive to maintain, and is only suitable in large cities for streets where the traffic is not very great or heavy.

2. The experimental work carried out in recent years with macadam improved by using a bituminous binder should be continued in order to determine the best methods of utilizing this kind of construction under varying conditions, so that this question may be submitted again at the next Congress.

3. Stone pavement has great qualities of resistance and durability. Its maintenance is easy and economical, it produces practically no dust, and is suitable where there are tramway tracks.

4. Stone pavement should be adopted in thoroughfares, wherever noise is of little consequence, or when wood or asphalt surfaces are not suitable. It should consist of blocks which are regular in shape, durable but not slippery, and will wear evenly. The blocks should be laid with close joints upon a foundation.

5. The Congress expresses the wish to see the trials of small block pavements continued wherever local circumstances and traffic conditions permit.

6. Wood paving is noiseless, is not slippery if kept clean and stands very heavy traffic. The use of it should be extended even to thoroughfares through which tramway lines run.

7. The respective advantages of soft and hard wood blocks must be a subject of discussion at a forthcoming Congress.

8. Asphalt pavements should be recommended, owing to their good qualities from the hygienic point of view, their ease of cleansing and of repair, and the small tractive effort required on them. This surfacing is almost noiseless and produces but little dust, but it is unsatisfactory adjacent to tramway rails.

9. There is opportunity for its use in fashionable thoroughfares where the traffic is not severe, where there are no tramways, and where the gradients are very moderate.

10. Finally, the trials of asphalt flag and block pavements should be continued with regard to those qualities not yet determined.

Sixth Question

Methods of Carrying out Road Work in Connection with Lighting and Water Supply.

1. It is desirable to free as far as possible the carriageway from the minor distribution systems which now encumber them, and to leave in them only the large sewers and mains which require little attention.

2. As far as possible the minor distribution mains which are connected to the adjoining houses should be doubled and placed on both sides of the street. This doubling is especially recommended for streets with heavy traffic and also for those where the surface rests on a solid foundation.

3. It is advisable to consider the advantages of placing all distribution systems, except gas, in subways of suitable dimensions placed under the footways. In this case great care must be taken to prevent flooding caused by breakage of water pipes.

4. When the distribution works have been placed under the carriageway, the Congress advises that the double system should be gradually adopted by taking advantage of the opportunity given by considerable repairs or alterations.

5. Complete agreement is necessary between all authorities interested in the streets, in order to conduct their

operations so as to interfere as little as possible with the traffic. It is most desirable that all street works should be under the general direction of those responsible for maintaining the surface. The work must be carried out as rapidly as possible so as to reduce both the space occupied on the public highway and the obstructions to traffic to a minimum.

6. Trees, planted in the footways in urban districts, should be selected so as not to inconvenience the property owners by their leaves nor interfere with the distribution systems by their roots.

Seventh Question

Influence of Weight and Speed of Vehicles on Bridges and Other Special Structures.

1. The development of mechanical traffic has not up to the present increased the weight of vehicles beyond the limits recognized by specifications in connection with bridge design. In any case it is desirable that, when existing specifications are revised, steps should be taken to test bridges by placing upon them under the most unfavorable conditions, the heaviest probable loads, composed exclusively of mechanical vehicles.

2. Under the present conditions of constructing motor vehicles and building public roads it does not seem possible that the speed of vehicles could have any effect on modern and well built bridges which has not already been duly taken into account by the usual methods of calculations of strength. It may be advisable, however, when testing new bridges or retesting existing bridges to make use of the heaviest motor driven vehicles running at high speed.

3. The consolidation of the different parts of which

bridges are composed aid their capacity to withstand the effects of vehicular traffic.

Eighth Question

Road Vehicles. Conditions to be Fulfilled by Horse or Mechanically Driven Vehicles in Order that They may neither Cause nor Suffer any Extraordinary Damage to or from the Roads.

1. With regard to animal drawn vehicles:

a. Heavily loaded vehicles with narrow tires may cause exceptional damage to roads constructed for general traffic.

b. It is desirable that trials be undertaken for the purpose of determining the relation which should exist between the load, the diameter of wheel, and the width of tire so as to avoid abnormal damage.

2. With regard to mechanically driven vehicles:

a. Automobiles of the touring car type cannot cause abnormal damage to the roads as long as their speed is kept within limits;

b. Public service automobiles cannot cause appreciable damage to the road provided that the maximum speed does not exceed 25 kilom. per hour, the maximum axle-load does not reach 4 tonnes on the heaviest axle and that with wheels of 1 meter diameter the load is below 150 kilog. per centimeter width of tread.

c. Industrial automobiles need not cause exceptional damage to a well constructed road provided that the following limits are adhered to:

First type: vehicles in which the axle-load is less than $4\frac{1}{2}$ tonnes:

Maximum speed: 20 kilom. per hour.

Load on tires: 150 kilog. per centimeter of width of tire with wheels of 1 meter in diameter.

In the narrow streets in towns and large cities when vibrations of the ground are to be feared, it is possible to minimize the inconvenience by reducing the speed in suitable proportion.

Second type: vehicles in which the maximum axle-loads are between $4\frac{1}{2}$ and 7 tonnes:

Maximum speed: 12 kilom. per hour.

Load on tires: 150 kilog. per centimeter of width of tire with wheels of 1 meter in diameter.

Provisionally, while awaiting the results of further experiments, when the diameter of the wheels is above 1 meter, the load per centimeter width of tire should be calculated, for both types of vehicles and also for such as are described in paragraph 2, by using the formula

$$C = 150\sqrt{d}$$

where d = diameter in meters and C = the load in kilograms.

It is desirable that experiments should be undertaken in order to determine the maximum width which can be given to the tires of all automobiles while still insuring, under normal conditions, that the distribution of the load on the ground should take place over the whole carrying area.

d. Ribbed or grooved iron tires cause abnormal damage to the road independent of their width or the load they support.

e. Vehicles propelled by mechanical power cannot

cause extraordinary damage to the curved portions of roads provided that at these points a sufficient super-elevation is given and that the curved portion is not approached or traversed at an unreasonable speed.

f. With a view to saving the roads, it is desirable that the car builders go carefully into the question of clutches and brakes so that the skidding of the wheels may be avoided; that they also balance the motors as perfectly as possible; and that they allow a reasonable raising of the center of gravity.

Ninth Question

Conditions for the Use of Public Service Conveyances other than Tramways. Advantages and Disadvantages, Capacity, Cost, Etc.

1. The Congress is of the opinion that public motor omnibus service should be encouraged.

2. As a final resolution, the Congress is of the opinion that it is difficult at the present moment to decide definitely on the respective advantages of the two modes of transport but that one forms the complement of the other and not the rival, and the adoption of one or the other method largely depends on local conditions.

3. The progress of the motor omnibus and extent of the use of this method of transportation is capable of great extension:

a. By the use of wheels fitted with rubber tires.

b. By any progress made in construction.

4. The number of passengers carried by motor omnibuses should be greater for the town than for the country.

APPENDIX I

PROCEEDINGS OF THE PERMANENT INTERNATIONAL COMMISSION

A meeting of the Permanent International Commission of the Association was held at Brussels on July 31st, 1910. It was attended by forty-four members representing eighteen countries.

M. Mahieu, Secretary-General of the Association, announced that M. Lethier, President of the Association, was prevented from attending the meeting by illness. M. de Préaudeau, Vice-President of the General Council of Bridges and Roads of France, upon unanimous request, acted as President.

M. Mahieu stated that twenty-six governments were affiliated with the Association and that the number of permanent members had now reached 723.

It was announced that the Executive Bureau was occupied with the establishment of a library which would include all literature concerning roads published throughout the world. Although it is expected that many books, reports and other publications will be furnished gratuitously, the budget provides for an expenditure of 200 dollars for additions to the library.

M. Mahieu also reported on the foundation for a Laboratory. Arrangements have been completed with the Minister of Finance of the Department of Public Works of France by which the Association will have the use of the Laboratory of the National School of Bridges and Roads

by the annual payment of 600 dollars. The following regulations have been drawn up covering the administration of the Laboratory.

Article 1. The Permanent International Commission shall determine each year the nature and the extent of the research work of the Laboratory which the Executive Bureau is authorized to undertake during that period.

Article 2. The substances required for the research work and the necessary analyses will be collected by the Executive Bureau.

The results of the research work of the Laboratory shall be the exclusive property of the Association: they will be sent to all the Members of the Association, in the form of an annual report of the Executive Office, with a simple indication of the source of origin. The names of the suppliers of the samples shall only be published with their written consent.

Article 3. The report shall not contain any criticism on the relative value of the various products analysed or experimented with.

Article 4. No paid analyses for third parties, even if members of the Association, will be made by the Executive Bureau.

Articles 6 and 17 of the Regulations of the Association were modified so as to read as follows:

Article 6 (last paragraph): "It shall administer the Funds of the Association and invest them in bonds of the French Government, in Debentures of the Railways guaranteed by the French State, or in Debentures of the Premium Bonds of the Crédit Foncier de France and of the City of Paris. It shall represent the Association in all judiciary actions."

Article 17 (first paragraph): "The discussions at a plenary meeting or sectional meeting shall take place in the languages accepted by the Congress and, according to circumstamces, in the language of the country where the Congress is being held. The speakers, however, are authorized to use their own language under the express condition of translating or causing to be translated the words spoken into one of the three accepted languages of the Congress. This translation will appear in the transactions provided for under Article 20, and the original speech will only be mentioned as having taken place."

The following very important resolution was adopted by the Commission and hence will apply to the regulations governing the 1913 Congress.

"That the reports be restricted to one report per country on one given subject, it being understood, however, that Governments, Corporate Bodies, and private individuals shall always have the right of defraying personally the costs of supplementary reports which they think should be published on any question which interests them in a particular manner."

APPENDIX II

REGULATIONS OF THE PERMANENT INTERNATIONAL ASSOCIATION OF ROAD CONGRESSES

Approved by the Permanent International Association in its meeting of the 29th of March, 1909

1. Object and Organization of the Association

ARTICLE 1

The object of the Permanent International Association of Road Congresses is to promote progress in the construction, traffic and exploitation of roads.

It continues the work of the first International Road Congress held in Paris, in October, 1908.

It accomplishes its object:

1st. By organizing Road Congresses:

2d. By publishing Papers, Proceedings, and other Documents;

3d. By collecting the results of: (a) Tests carried out on roads; (b) Laboratory tests throughout the world on materials which are used or are suitable for road construction and maintenance; these tests may be either in the form of mere records collected by the Association or they may have been carried out by the Association itself or through its instrumentality.

Its affairs are managed by a Permanent International Commission.

Article 2

The **Association** consists of:

1st. Delegates of Governments and Corporations of all the countries which subscribe annually to the Association.

The term Corporation includes: Public departments, Provincial Governments, County, District, Communal and Municipal Bodies, Chambers of Commerce, Scientific or Technical Institutions, Tourist and Sporting Clubs, Professional Associations or Trade Unions, Transport Companies, Agricultural, Industrial and Commercial Societies or Companies, etc.

2d. Private Members.

Membership may be either permanent or temporary.

Governments may appoint one official delegate, with a right to vote at every Congress, for each 50 dollars of their annual subsidy.

This amount is reduced to 20 dollars for Corporations.

Permanent Members are entitled to attend and vote at every Congress.

Temporary Members are entitled to attend the particular Congress they have joined, and they may vote on all questions which do not affect the Permanent Association itself.

3d. Honorary Members, nominated by the Permanent International Commission.

Article 3

1st. A Permanent International Commission, with headquarters at Paris, is at the head of the Association.

2d. A Permanent Council and an Executive Committee are appointed from amongst the Members of this Commission.

Article 4

The Permanent International Commission is composed of members belonging to the various countries represented in the Association. Each country has the right to one representative for each 200 dollars of its total annual subsidy.

Provided, however, that the number of representatives from any one country shall not exceed 15 (fifteen), and that any country which pays not less than 50 dollars shall have the right to appoint one delegate.

Furthermore, the General Presidents and the General Secretaries of the Road Congresses are *ex-officio* Members of the Permanent Commission.

At the head of the Permanent Commission there is a President, a Vice-President and a General Secretary who together constitute the Executive Committee.

This Commission:

1st. Determines when and where the first Congress shall be held.

2d. Arranges at the proper time for the formation of a Local Organizing Commission at the place selected for the Congress.

3d. After consultation with the Local Organizing Commission, determines the languages which shall be officially recognized by the Congress; prepares the Agenda and settles the questions to be submitted to the Congress as also the nature and number of the communications it shall deal with; arranges the business of the Meetings; and appoints the writers of Papers on the several questions.

4th. Supports, when necessary, the Local Commission in its application to foreign Governments.

5th. Approves the estimates of expenses to be defrayed out of the permanent funds of the Association; supervises the financial management; and decides, generally, upon all the administrative measures which it considers may promote the work of the Congress.

6th. Nominates Honorary Members.

The Commission meets whenever it is convened by the Executive Committee, or upon the written requisition of a quarter of its Members addressed to the President of the Executive Committee, and, at any rate, at the time of the Congress Sessions.

The Members of the Permanent Commission, who do not find it possible to attend a meeting, may delegate their powers to one of the Members of the Commission.

Article 5

The Permanent Council is composed of representatives chosen from among the members of the Permanent Commission, namely:

One for each country whose annual subsidy does not exceed 1000 dollars;

Two for each country whose annual subsidy exceeds this amount, and is less than 2000 dollars.

Three for each country whose annual subsidy exceeds 2000 dollars.

The President, Vice-President and General Secretary of the Permanent Commission are at the head of the Permanent Council.

The Permanent Council:

1st. Carries out the resolutions of the International Commission, and decides upon all questions not expressly reserved for the decision of the Commission.

2d. Decides upon the admission of Corporations and Permanent Members referred to in Article 2.

3d. Draws up the estimates to be defrayed out of the permanent funds of the Association, and assists and controls the Executive Committee.

4th. After having requested proposals from the Local Commission the Council proceeds to appoint the General Committee and Sectional Committees of the next Congress, appointing as Vice-Presidents on each Committee three Members of the Permanent Commission who are familiar, as far as possible, with the languages officially recognized by the Congress, and it also appoints Secretaries who are well versed in these languages.

5th. The Council meets whenever convened by the Executive Committee, or upon the request of one-fourth of its Members addressed to the President of the Executive Committee.

Article 6

The Executive Committee, as stated under Article 4, is composed of the President, Vice-President and General Secretary of the Permanent Commission and of the Permanent Council. In addition to an Accountant, it may appoint Secretaries who shall be specially entrusted with the translations and a Secretary who shall have special charge of the head office for laboratory experiments on materials used in the construction and maintenance of roads.

The Members of the Executive Committee shall belong to the country in which the headquarters of the Permanent Commission are situated.

It collects the records of experiments carried out on roads throughout the whole world and the records of labora-

tory tests in all countries on materials used in the construction and maintenance of roads; it arranges for fresh experiments to be carried out and if necessary carries them out itself.

It is specially concerned in specifying the conditions which shall be complied with by all those materials, whatever their nature, such as tars, mineral oils and other kindred products, which are used or can be used practically in the construction and maintenance of roads.

It attends to the despatch of current business, keeps the accounts, prepares the estimates of expenses to be defrayed out of the permanent funds of the Association, keeps the expenses within the limits of the approved estimates, signs checks, and collects subscriptions and all other money due to the Association.

It deals with all investigations, tests, and occasional or periodical publications decided upon by the Permanent Council or by the Permanent Commission.

It has charge of the library, archives, documents and accounts.

It translates, when necessary, publishes and transmits to the Members of the Congress, the papers, communications and proceedings of the Congress.

It handles the funds of the Association and invests them in French Government securities or in French railway debentures guaranteed by the State and represents the Association in legal proceedings.

Article 7

The representatives of the various countries, both on the Permanent Commission as well as on the Permanent Council, are appointed by the Governments of the respective countries in the proportions stated in Articles 4 and 5.

It devolves upon the Government of each country, whenever occasion arises, to fill vacancies which may occur amongst their representatives on the Commission or on the Permanent Council, through death or through the expiry of their term of office.

ARTICLE 8

Each Congress entails the appointment of a **Local Organizing Commission** which includes the local Members of the Permanent Commission and holds office till the close of the Congress.

This Commission includes committees of patronage, administration, reception, excursion, and others.

It undertakes the propaganda in the country where the Congress is to be held, and, in accord with the Permanent Council, selects persons in that country for Presidents and Members of the Committee and Sectional Committees of the Congress.

It draws up, in consultation with the Permanent Council, the detailed program of the Meetings, and distributes it to all the Members of the Congress at the opening of the Session.

It organizes the various excursions, receptions, and fêtes.

It provides the rooms in which the Meetings are held.

It advises the Permanent Commission on the languages which may be officially recognized by the Congress and on the translations which have to be made for the Session; the language of the country in which the Congress is held, will have to be admitted, if required by the Local Commission.

It organizes the service of correspondence, lodgings, interpreters, and helps where necessary the Permanent Commission in arranging at the expense of the Association

for the translation and printing into the language of the country where the Congress is held, of Papers which have been written in any of the other languages officially recognized by the Congress.

Conversely it arranges at the expense of the Association for the translation, into any of the other languages recognized by the Congress, of Papers which have been written in the language of the country where the Congress is held.

It puts the Permanent Commission into touch with the local authorities.

It presides over and conducts the Session of the Congress.

It defrays the expense of the Congress by means of the subscriptions of the temporary members, fixed at five dollars, by other special grants, and, if required, by a subsidy from the Association.

It keeps a special account of the expenditure of the subsidy which may be granted by the Association, and it may not, without the authority of the Executive Committee, incur any expense on behalf of the Association, beyond the aforesaid subsidy.

Article 9

The permanent funds of the Association are derived from:

1st. The annual grants from Governments and Corporations.

2d. The subscriptions of permanent Members (see Article 2).

Permanent membership involves a yearly subscription of two dollars. This subscription is increased to five dollars, for the first year, in the case of permanent Members who are

enrolled during a Congress year. Permanent Members may pay in the fees of three consecutive years at once. Honorary Members pay no subscriptions.

3d. Various donations and gifts.

Article 10

1st. **The financial year** commences on the first day of January.

2d. **Subscriptions** are payable as follows:

Permanent Members: at the time of enrollment, and on January of each year, in advance, to the Office of the Executive Committee.

Temporary Members: at the time of enrollment, to the Office of the Local Organizing Commission.

The expenses of collection must be borne by the Members.

Special subscriptions may be solicited by the Local Organizing Commission from the Members who take part in the excursions and fêtes during the Congress. Participation in these is optional, and the number of the participants may be limited.

Article 11

Every Member is entitled:

1st. To take part in the Meetings of the Congress and to vote upon all questions submitted.

2d. To receive the publications of the Congress, in any one of the languages recognized by the Congress, which he may select. The Association is not bound, however, to replace copies which are lost or damaged in transit.

Permanent and Honorary Members are further entitled:

(a) To lay before the Permanent Commission any questions to be submitted to the Congress. Such questions, accompanied by a concise report giving reasons for the same, must reach the Commission at least one year before the Meeting of the Congress.

(b) To vote on all questions depending on the Permanent Association at the meetings of the Congress or at the special meetings.

(c) To receive the publications distributed by the Association at other times than during the sessions of the Congress.

The number of copies of publications sent to Governments and Corporations is determined on the same basis as the right to vote. (Article 2.)

Each Government or Corporation, whatever the amount of its contribution, receives at least one copy of the publications.

II. Sessions of the Congress

Article 12

The Permanent Commission convenes the Congress from time to time, at intervals of about three years, as nearly as possible.

Article 13

1st. The Congress comprises:

Two Sections: One for the construction and maintenance of roads and the other for traffic and exploitation.

These Sections may be subdivided.

2d. Its proceedings consist of General Meetings, Sectional Meetings, Excursions and Receptions.

The number and nature of the questions to be discussed by the Congress are settled by the Permanent Commission. This Commission also settles the number and nature of communications which may be submitted to the Congress in addition to the ordinary program of questions.

As a general rule each country shall only furnish one Paper on any given "Question" or topic of a "Communication."

Article 14

The Reporter or Reporters, selected by the Commission for any given question or topic of a communication and for any given country, shall collect in that country all the data needed for the preparation of their Paper.

Their work, supported by conclusions if they deem these desirable, should reach the Executive Committee, at the latest, eight months before the opening of the Congress.

The Permanent Commission appoints a General Reporter for each question, whose duty shall consist of submitting to the Congress a short review of the chief features of this question, together with a summary of the Papers which have been transmitted to him.

The General Reporter may give his own views and data, and he may arrange with the various authors of Papers for formulating joint proposals. As far as possible, he shall belong to the country in which the Congress is held.

Article 15

The Papers upon each "Question," and also the General Reports must be forwarded to the Executive Committee within the limit of time allowed to their Authors;

they will be translated and printed in the official languages of the Congress.

The Papers must be written in one of the official languages of the Congress and should be typewritten if possible on one side of the paper only.

Each Paper should not exceed about 8,000 words, the number of illustrations inserted in the text should not exceed 6, and the total surface occupied by them should not exceed 46.5 square inches.

The plates separate from the text, either drawings or half-tones, should not exceed two in number, except in special cases. Their size should not exceed 9.4 inches in depth by 17.7 inches in width, including the border line, or 8.7 inches by 17.0 inches within the border line.

The drawings should be made in clear black lines on tracing paper so as to allow blocks to be made from them if necessary.

The "Communications" are not translated and are not submitted for discussion during the Session of the Congress until after the "Questions" in the Agenda have been dealt with, and then only if time permits.

In addition to the "Communications" referred to in the above articles 13 and 14, which are printed at the expense of the Association, the Permanent Commission may admit "Communications" printed by their Authors at their own expense; in the latter case the required number of copies must be supplied to the Executive Committee and furthermore they will not be voted upon, nor brought up for consideration at a General Meeting.

Writers of Papers upon "Questions" or "Communications," may, if they wish, furnish their own translations into the various official languages of the Congress.

ARTICLE 16

The "Questions" are first discussed at the Sectional Meetings and afterwards at a General Meeting.

ARTICLE 17

1st. **The discussions,** either at General Meetings or at Sectional Meetings, are conducted in the languages officially recognized by the Congress, and also, when required, in the language of the country where the Congress is held.

2d. Unless otherwise decided by the Meeting, persons taking part in the discussions are not allowed to speak for more than ten minutes, nor can they address the same Meeting more than twice upon the same subject unless the Meeting, on being consulted, decides otherwise.

3d. The discussion in Sectional Meetings or in General Meeting will be preceded for each question by a brief summary of the reports by the General Reporter who has been appointed under the terms of Article 14.

After discussing each question submitted to it, each Section may appoint one or more reporters to support in the General Meeting the conclusions they have adopted.

ARTICLE 18

Members of the Congress who have spoken at a Meeting must, within twenty-four hours, deliver to the Sectional Committee a summary of their remarks, to enable a report of the proceedings to be drawn up.

In the case where the summary has not been submitted, the wording adopted by the Secretary or even the mere heading will be mentioned instead.

The Committee shall have the right to request the

author to abridge his summary, and should it not have been revised and amended in due time, the Committee will undertake the abridgement.

Article 19

The summary of the discussions, arranged and edited by the Sectional Committees, together with the various conclusions adopted by the majority of the Members voting, are transmitted by the General Reporter to the Permanent Council the day before the last General Meeting and they are then laid before the latter where they are discussed and voted upon.

Article 20

A detailed report of the Proceedings of each Section of the Congress is prepared by the Executive Committee assisted by the Committee of the Congress and especially by the Vice-Presidents and Secretaries mentioned in Article 5.

As regards the General Meetings and Excursions, a similar report is prepared by the General Secretary of the Session within the shortest time.

The joint record so compiled is published, under the direction of the Executive Committee, in the languages officially recognized by the Congress.

III.—Dissolution of the Association

Article 21

The dissolution of the Association can only be effected at a Congress specially convened for the purpose, and must be approved by a majority of three-fourths of the Members present and entitled to vote.

Article 22

1st. In the event of its dissolution, the liquidation of the accounts of the Association shall be undertaken by the Permanent Commission.

2d. The final assets of the Association shall, under its guidance, be devoted to philanthropic or technical objects relating to roads.

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